HYGIENE AND EFFICIENCY

FOR

THE TUBERCULOUS

By

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FOREWORD.

If the arrested tuberculous man is to stand on guard against relapse, to preserve his health and to carry on with efficiency, he must be trained to do so. He must be fortified by information on tuberculosis that will enable him to perceive the earliest symptoms of relapse. He must be in possession of certain information on hygiene and established in health habits, and he must be trained for a job that will require an energy outgo that is less than his energy income. So trained, the tuberculous man is prepared to live a successful life, enjoy a reasonable amount of good health, and reduce his likelihood for relapse to the minimum.

Health is not a gift. It comes from toil and effort. There is no easy or royal road leading to the desirable state of health. To the few the necessary adjustments to secure health do not obtain, but for the majority a knowledge of how to live expressed in proper hygienic habits will bring about a sufficient degree of health to live a worth-while life. It is true that the tuberculous person can not have an abundance of health like his neighbors, but within his limitations he may be relatively just as healthy.

Health is a matter of adjustment—adjustment of the many cells of the body to each other and the body to its surroundings—environment. Hygiene is the science of this adjustment. It teaches those facts which are essential in the adjustment of the body cells to each other and the body to its environment. The study of hygiene is based on an understanding of natural phenomenon. A knowledge of physics and chemistry. It is necessary, therefore, that the laws of physics and chemistry that are concerned in the laws of hygiene be explained and demonstrated. Starting from known or observed facts, physical and chemical, one can proceed by sound pedagogical principles to an understanding of the laws of hygiene. It is true that the life principle is still more or less a mystery, but the mysterious is growing less and less with our increasing knowledge of natural laws. It is possible to explain most of the phenomena of life on a scientific basis. Secondly, in the adjustment of the body to its environment, certain economic, industrial, and recreational knowledge is necessary. From the negative side, modern hygiene should not consist of lists of anatomical facts nor be a graveyard of bones. It should avoid the morass of mysticism and the inclusion of facts that are not of practical use in understanding the laws and principles of hygiene. To be most useful it must be nontechnical, simple, in the language of the earlier years of the junior high school.

Preparation of this text has had for its purpose the assisting of the tuberculous man in his readjustment back into society as a healthful, economic, and self-supporting unit. The writing of this book

has been an act of conscience. In spite of contrary opinion and belief, it has been written with the purpose of training the ex-tuberculous man so that he may become in a sense his own personal physician. He will still need the trained physician for consultation, but for deciding the little things in life and for standing on guard against a relapse he will possess sufficient knowledge. It may be argued that a little knowledge is a dangerous thing, but knowledge is power and human endeavor is weak. It tends to go along the lines of least resistance. The tuberculous man, unless he knows his condition, his physical and mental limitations, and the reasons why he must sacrifice, will not make the necessary adjustments. He does not understand why he should, and he does not know how he may, so, with an abiding faith in the ex-service man and with a desire to aid him in overcoming his handicap, the author has labored to supply the tuberculous man with a vision of his possibilities, to teach him facts that will establish his health habits and enable him to go over the top in civil life as an efficient citizen.

This text is a preliminary study. It is put forth as a working basis for a course in hygiene. The author desires criticisms and he will welcome suggestions as to its betterment. It is suggested that classes be arranged, and that the text be used as a basis for classroom work, supervised study, recitations, lectures, and demonstrations. Where desirable, it is believed that correlated work in English and mathematics may be developed. Special effort should be made to carry out the demonstrations and projects. For the most part they require simple apparatus, and a little enterprise will improvise the necessary material.

WASHINGTON, D. C., *June 21, 1922.*

HYGIENE AND EFFICIENCY FOR THE TUBERCULOUS.

By John W. Turner, A. B., M. D.

INTRODUCTION.

THE HUMAN BODY—A COMMUNITY OF CELLS.

THE ANCIENT IDEA OF THE BODY.

The ancient Greeks thought of the human body as similar in form to that of the Deity. They believed their gods were like unto themselves, but more perfect and beautiful and having life everlasting. In the Bible the Hebrew writer tells us that God walked and talked with Adam and Eve in the Garden of Eden. The Bible says God created man in his own image and likeness—a living soul, and he likened our bodies to earthly temples with the command that we should keep them holy. Some have thought that the word "holy" in this connection means "healthy." The Bible says that man should live three score years and ten; that is, 70 years. This should be easy to do, for it is instinctive to want to live; it is one of the strongest instincts possessed by mankind. It is seldom indeed that one reaches a state of mind where he wants to die. It is only when the body temple has become decayed through disobedience to the laws of health and by disease germs that the body becomes an unfit place for the soul and the spirit leaves. Death is the result. It is a separation of the soul or spirit from its earthly temple.

THE MODERN IDEA OF THE BODY.

The moderns think of the body as a machine for doing work. As a mere machine for doing common laboring work it is rated as being worth $10,000. It may be compared with a steam engine. There are many points in common. The steam engine gets its energy by burning coal in its fire box; the body gets its energy by burning up digested food. "How can that be?" some one asks. Well, let us see. What occurs when wood or coal burns? That is simple, you say. Smoke goes up the chimney, heat is given off, and ashes remain. In reality, however, it is a union of oxygen with the carbon and hydrogen in the wood or coal. To put it another way, burning is the union of oxygen with any other substance. It is called oxidation. You know how a fire burns low and may go out if the stove or furnace is closed tight so that the air can not readily enter. The air contains oxygen, and without oxygen the fire can not burn. You have all noticed that when one runs or

works hard he becomes warm and begins to breathe faster and deeper. Why does his breathing increase if it is not to get more air into his lungs so that he may get more oxygen to his muscle cells? His muscle cells need oxygen for combustion just as the fire does. In short, when one exercises he breathes faster and gets warmer. For, as a matter of fact, the food that he eats corresponds to the coal in the fire box of the steam engine, and the food, while it is burned up differently and more slowly, it really burns up just the same and in burning furnishes heat and energy.

THE BIOLOGIST'S IDEA OF THE HUMAN BODY.

The student of animal life (the biologist) thinks of the human body as a mass of matter and energy; a collection of living units or cells which live, grow, and die, all working together for a common purpose. He believes that the foundation of life is the cell; that life exists only in the cell, and no matter how many cells there are in the animal, every cell is alive, and that the animal really lives his life in his cells. The many-celled animal is more alive because he has more cells in his system. The biologist says that it is an advantage to have many cells; that with the increase in cells there is an opportunity for a division of labor, just as there is in a modern community where every citizen may have his special job. Some citizens make shoes, some clothes, some bake bread. The farmer raises food and vegetables; the railway carries it from the farm to the city. The policeman guards, etc. Everyone, if he is doing a worth-while job, is doing something for the benefit of his fellow citizens, who, in turn, are doing something for him. In short, as everyone is dependent on the community for existence, so in the many-celled animal every cell has its special work to do; some become hard and protective; some cells digest food; others carry this digested food to the different parts of the body and carry away the waste materials, and every cell is dependent on the other cells in that animal for its needs.

The biologist tells us that the study of life begins with the one-celled animal. He says that they have all the properties of life that are observed in the higher animals. He takes scum from a pond; he places it under a microscope. Through the microscope he sees little one-celled animals. He watches them move, feel, take up food, grow, and finally divide into two animals. He says that they have all of the five properties of living beings or organisms: (1) Motion, (2) sensation, (3) assimilation (digestion), (4) growth, and (5) reproduction.

LIFE—ITS RELATIONSHIP TO MATTER AND ENERGY.

Life is a quality possessed by animals and plants as well as by man. The biologist says that life may be a specialized form of energy and that so far as known life can not be or exist except in matter and by the release of energy. We know many things about life, what it does, but just what it is and where it comes from is more or less a mystery. We know that life comes from life; and that every living thing starts as a unit or cell. That this first cell divides into two

cells and these two cells divide into four cells and so on into many, innumerable in the higher animals, but that, great as is their number, they all came from one parent cell, and because of their ability to cooperate and through a division of labor—that is, specialization—the many-celled animals have become much more complex and efficint, they are better able to adjust themselves to their surroundings or environment. But before taking up further study of the body cells it is necessary to review our knowledge of matter and energy.

PART I.

METABOLISM.

CHAPTER I.

MATTER AND ENERGY.

MATTER DEFINED.

Matter is anything that has weight. It may be a solid, a liquid, or a gas and may be changed from one of these forms into another (1) by the addition or the subtraction of heat. For example, ice plus sufficient heat equals water, and enough heat added to water will turn it into steam. On the contrary, the subtraction of heat from steam turns it into a liquid, and the further subtraction of heat turns the liquid into a solid ice. Matter is changed in form (2) by chemical action. For instance, two gases, hydrogen and oxygen, may be burned, producing steam. The steam on cooling turns into water. The amount of water by weight that is formed is equal to the weight of the two gases burned up. Electricity can be run through this same amount of water and the water will be turned back into the same amount of hydrogen and oxygen that was burned. The point is that while matter may change form and appearance there is no loss or destruction of it. One may burn coal in a stove, but the ashes and smoke contain all the matter that was in the coal, but in a different form. The ashes and smoke weigh as much as the coal and oxygen burned up. Matter is continually changing. The plant changes mineral matter to vegetable matter, the animal uses the plant as food. When the animal dies his body goes back to the soil and is again used by the plant, to be reused again by the animal. Matter may be changed but it can not be destroyed. Nothing is lost and nothing is added. The earth, except for the meteors that have fallen upon it, weighs the same to-day as it did 1,000 years ago.

ENERGY DEFINED.

Not so with energy. It comes, and if not used or stored up, it quickly passes away again into space from whence it came. The sun is the source of nearly all earthly energy. Its rays bring light and heat. Without these daily supplies of energy the earth would grow colder and colder until finally all life, animal and plant, would die. Energy is ability to do work. It is stored-up power. It works through matter and often seems to be, and may wrongly be called, matter. For example, coal is often spoken of as black energy, just as falling water may be called liquid energy. Energy should be

thought of as light, heat, motion, power, and electricity, but not as something that can be weighed. Energy can be changed from one form into another and back again. For example, the steam engine turns heat into motion; that motion and power may turn a dynamo to making electricity. This electricity may be turned into light when run through an electric lamp, or back into heat when run through an electric stove.

How energy is measured.—Energy can be measured just as we measure distances in inches or weight in pounds. Energy is usually measured in terms of heat. The heat unit is called a calorie. It corresponds to the inch in the measure of distances. A calorie is the amount of heat necessary to raise the temperature of 1 kilogram of water 1 degree centigrade or 1 quart of water 2 degrees Fahrenheit. In terms of power it is the force that will raise 1 ton 1.54 feet. For example, one usually buys coal by weight, but large factories buy it by the amount of heat it will produce; that is, the amount of energy it contains. The energy value of foods is measured in calories. While energy is not a part of matter, they are closely associated. In the formation of compounds by combustion, energy is released or liberated.

ELEMENTS AND THEIR SYMBOLS.

Matter in its simplest form is composed of one of the eighty-odd elements: Gold, silver, iron, carbon, oxygen, hydrogen, etc. Elements are simple substances. They can be divided down to the very last part with no change in the substance. Every element has its symbol or initials, by which it is known. For example, C stands for carbon: O for oxygen: H for hydrogen; Ag for silver, etc. Compounds, on the other hand, are composed of two or more elements joined together in such a way that a new substance is formed.

Demonstration No. 1.

Demonstration by the teacher showing decomposition (the breaking up of water) into two gases, oxygen and hydrogen, by electricity.

COMPOUNDS AND THEIR SYMBOLS.

Compounds have their symbols or initials, as, for example, water has H_2O as its symbol because every particle of water contains 2 atoms of hydrogen and 1 of oxygen. There is a 2 written after the H to indicate that there are 2 atoms of hydrogen. A number 1 is understood after O to indicate that there is 1 atom of hydrogen. Upon the division of a compound at last a point is reached where any further division will result in a separation of it into the elements from which it was made. For example, water may be divided to a point where any further division will result in oxygen and hydrogen being formed. Energy is usually released when elements are united into compounds. For example, in the burning of coal, which is carbon and hydrogen, heat is produced because the carbon and hydrogen of the coal are united to the oxygen of the air with the production of CO_2 (carbon dioxide), and H_2O (water).

How elements unite to form compounds.—Elements are united in a very definite manner. For example, it has been found that 1 unit or atom of oxygen can take up 2 atoms of hydrogen and that 1 atom of carbon can take up 2 atoms of oxygen. In other words, carbon has four times the combining power of hydrogen. If one will take acompound of carbon and hydrogen, he may be sure that there will not be more than 4 parts of hydrogen to 1 of carbon, just as a sponge can only take up so much water. It can not take up more, but it may take up less if there is a shortage of water. Or again, a quart of water at a given temperature will dissolve a certain amount of salt, but if less salt than can be dissolved is added, the water is able to dissolve more; if a greater amount than can be dissolved is added, it simply remains at the bottom of the dish. So, for example, carbon can take up 2 parts of oxygen, but if there is a limited supply of oxygen present, the carbon will combine with 1 part of oxygen. The compound formed in that case is carbon monoxide, CO. CO burns in the presence of air or oxygen because every atom of carbon is combined with only half as much oxygen as it can take up or unite with.

Bankers and spenders of energy.—Plant life is the great banker of energy. The plants store up energy, animals release it and spend it in heat and activity. The plant's method of storing up energy is not difficult to understand. It is able to store up energy because it is able to separate carbon from oxygen. The plant turns its leaves to the sun. The cells of the leaf, by the aid of the heat and light from the sun, are able to separate the compound carbon dioxide of the atmosphere into carbon and oxygen. All of the carbon and some of the oxygen is fixed; that is, it becomes part of the plant. The rest of the oxygen is given off as gas. Plants do not store up pure carbon. Plants develop complex compounds which are composed largely of carbon, hydrogen, oxygen, and nitrogen, with small amounts of minerals. These compounds that plant life build up contain some oxygen, but it is less than the other elements can take up. In other words, the elements stand ready to take up more oxygen; that is, they will burn. Therefore, one may say that while the growing plant uses up some energy, for life can not be without some expenditure of energy, it saves more than it spends. By its separating oxygen from other elements it develops substances that can be taken up by the animal and combined with oxygen for the liberation or releasing of energy; i. e., heat and power.

Where energy is released.—One must remember that the body does not create energy; that it can not give out more energy than is developed by combining other elements with oxygen. As has been said before, one may think of the body as a machine whose principal function is to unite or combine other elements with oxygen so that it may get the energy it needs. The combining of elements with oxygen takes place in the individual cell. The cells receive food which contains elements that may be united with oxygen. By their ability to unite these elements they are able to get the energy that is necessary for their own life and for that of the cell family or community in which they live. As we have learned, every cell is dependent upon every other cell in the body, but the muscle cells, which need great supplies of energy, are especially dependent on the cells

that deliver matter that will combine with oxygen with the release of energy. They must be supplied with oxygen. The waste materials that are formed in the slow combustion must be carried away. Energy can not be released until oxygen has combined with the other elements in the cell. Unless the lungs—the respiratory system—are able to furnish the blood with the necessary amount of oxygen and unless the digestive system is able to furnish the required amount of matter containing elements for a combination with oxygen, and the heart and blood are able to carry these materials to the cells, the body does not get energy. Not only must the supplies be delivered, but the waste matters that are formed in the union of the elements must be disposed of, for, as we shall soon learn, an accumulation of waste prevents the cells from carrying on as they should. The union of elements with oxygen in the cell is one of the vital functions of life. This union of the different elements with oxygen in the cell is really a form of combustion. A short study of combustion follows:

COMBUSTION.

Rapid combustion.—The union of any element with oxygen is called combustion. It is the same as burning. There are two kinds of combustion, rapid and slow. For example, iron rusts in the air. It is really a slow burning of iron. Rust is a combination of iron and oxygen. Iron burns slowly in the air, but in pure oxygen it burns very rapidly. The same substance is formed, namely, iron oxide. Combustion may be slow or fast, depending on conditions. It is always slow in the cells; it is usually rapid in the presence of air or oxygen. Fire is a good example of rapid combustion. It is a union of other elements with oxygen, resulting in the rapid release of large amounts of heat. We are all familiar with fire. We know that as the fire burns certain substances disappear and others take their place. For example, in the burning of coal, which contains principally carbon, hydrogen, and oxygen and some mineral matter, the carbon is changed to CO_2 (carbon dioxide), the hydrogen to H_2O (water), and the mineral matter remains as ashes, with CO_2 and H_2O given off in the smoke.

Slow combustion.—Since the days of prohibition more interest has been given to home brew. It has been found that fruit juices, grapes, cider, etc., if left to stand in the open will work and develop a "kick"—alcohol. This result is brought about by a small one-celled plant called yeast. Wild yeast floats in from the air. It starts to grow and multiply. It lives on the sugar in the fruit juices. The yeast plant takes up—that is, eats—sugar, digests it, and gives off CO_2 and alcohol. Most of the CO_2 bubbles away in foam, but the alcohol remains behind. Those who have made a study of the yeast plant tell us that in the yeast cell the sugar is burnt up, and that CO_2 and alcohol are the waste products of this slow combustion. It may be noted that the slow combustion in the yeast cell is not as perfect as the rapid combustion of sugar in the air, for in the yeast plant we have CO_2 and alcohol formed, whereas in the combustion of sugar in the air we have CO_2 and H_2O.

Yeast combustion.—It has been found that 1 atom of carbon (C) will take up 2 atoms of oxygen. For this reason carbon dioxide, which is composed of carbon (C) and oxygen (O) is written CO_2

because it contains 1 atom carbon (C) and 2 atoms of oxygen. It has been found that 2 atoms of hydrogen will take up 1 atom of oxygen. For this reason water which is composed of oxygen and hydrogen is written H_2O, because it contains 1 atom of oxygen and 2 atoms of hydrogen. It will be noted in H_2O and CO_2 that the carbon and hydrogen have all the oxygen that they can take up. The C and H in H_2O differ in this respect from the C and H in grape sugar, which is composed of 6 atoms of carbon, 12 atoms of hydrogen, and 6 atoms of oxygen (written $C_6H_{12}O_6$), because grape sugar contains less atoms of oxygen than its atoms of carbon can take up. This shortage of oxygen may be made clearer by adding up the number of oxygen atoms that the carbon and hydrogen can take up. Six atoms of carbon will take up 12 atoms of oxygen and 12 atoms of hydrogen will take up 6 atoms of oxygen. Together they can take up 18 atoms, but as there are 6 atoms of oxygen present, so 12 more are needed to completely satisfy the carbon and hydrogen atoms. Because of this fact grape sugar will burn. We were told in the paragraph above that the yeast plant took up grape sugar and that it gives off as waste, CO_2 and alcohol. Alcohol, chemists tell us, contains 2 atoms of carbon, 6 atoms of hydrogen, and 1 atom of oxygen. It will be noted that alcohol contains less oxygen in proportion to the atoms of carbon and hydrogen, but the C and H are still able to take up more oxygen, and for that reason alcohol burns. This shortage of oxygen may be made clearer by adding up the number of oxygen atoms that the carbon and hydrogen can take up. Two atoms of carbon will take up 4 atoms of oxygen and 6 atoms of hydrogen will take up 3 atoms of oxygen. Together they will take up 7 atoms of oxygen, but as there is 1 atom of oxygen present 6 more are necessary to completely satisfy the carbon and hydrogen atoms. It is clear therefore that grape sugar, in passing through the yeast cell, gains in oxygen. To put it in other words, we may say that the yeast plant burned up half of the sugar to CO_2 and excreted the other half as alcohol.

Protoplasm.—Every cell contains a living substance called protoplasm, which comes from two Greek words meaning "First life." Protoplasm is the vital, life-giving substance in the cell. Body cells differ in form, size, color, etc., but they all contain protoplasm. Protoplasm is composed largely of carbon, oxygen, hydrogen, and nitrogen. Protoplasm has the power to take in food substances. It has the power or ability to change these food substances so it can use them. Some of them it uses for energy and some for building up and repairing its own self. Protoplasm gets its energy, its power, by adding oxygen to the carbon and hydrogen in the food substances. This ability to add oxygen is somewhat of a mystery but it will be explained in part when we come to take up the subject of digestion. For this reason we will not consider now how the yeast adds oxygen to sugar, that is, burns to carbon dioxide and alcohol in its protoplasm.

The yeast plants continue to grow and multiply as long as there is sugar or until their waste (alcohol) becomes so strong that it destroys them. Alcohol is poisonous to the yeast cells just as it is to the body cells. All cells are affected by their wastes, it matters not whether they are yeast cells or body cells, but body cells have

means provided for getting rid of their waste, while yeast cells have not. The supplying of body cells with food and oxygen, and the taking away of their waste matters—gaseous, liquid, and solid—developed by slow combustion is most vital. It is accomplished by the respiratory system, the circulatory system, and digestive system.

EXPERIMENTS IN COMBUSTION.

Demonstration No. 2.

(By the teacher or a group of the class.)

Problem: To show that air has weight.

Apparatus and material: A football or a bicycle or auto tire pumped up.

Directions: Balance on a scales or beam balance and then let the air out. Note what happens.

Questions: Does the balance fall or rise on the side of the escaping air? Why should a tire pumped full of air weigh more than a punctured tire? Why does a tire get warm when air is pumped in?

Project No. 1.

Problem: To show that air occupies or takes up space.

Apparatus and material: A wide-necked bottle and a pan or dish filled with water.

Directions: Try to force the mouth of the bottle into the water, note what results.

Questions: Can we fill the bottle with water without letting the air out? Does this indicate that the air takes up space?

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Project No. 2.

Problem: To prove that a burning candle can not burn without air.

Apparatus and material: A small cork, a small dish or pan of water, a wide-necked bottle.

Directions: Float a piece of cork with small lighted candle on it in a dish of water, carefully cover the candle and cork with a wide-necked bottle and note what happens.

Questions: Why does the candle go out? Is all the air used up?

Demonstration No. 3.

(By the teacher or the class as a whole.)

Problem: To show that the products from a burning candle weigh more than the candle itself.

Apparatus and material: Balance or scales, a candle, some pieces of KOH, a lamp chimney, wire gauze, a few small pieces of wire, and two small blocks of wood.

Directions: Place the candle under a lamp chimney placed on two small blocks of wood and mold some wire gauze to fit the upper part of the lamp chimney and fill with pieces of KOH in one pan of the scales and sand in the other pan and light the candle and note results.

Questions: Why does the pan holding the burning candle finally go down? Something must have been added. Where does it come from?

Project No. 3.

Problem: To prove that H_2O is one of the products formed in the burning of the candle.

Apparatus and material: A small cork, a small dish or pan of water, a wide-necked bottle.

Directions: Hold a cold wide-mouthed bottle over a burning candle. The cold glass will cool some of the gaseous H_2O to liquid H_2O and it will be seen collected on the outside of the bottle.

Questions: Can one see steam? Are you sure that the dew-like liquid seen on the outside of the bottle comes from the burning candle?

Project No. 4.

Problem: To show that CO_2 is one of the products formed by a burning candle.

Apparatus and material: A small cork, a small dish or pan of water, wide-necked bottle, some lime water, a candle.

Directions: Hold a bottle as before, turn right side up and add a small amount of lime water and shake. The lime water becomes a milky white. As there is no other odorless and colorless gas that gives this reaction with lime water it is a very reliable test for CO_2 (carbon dioxide.)

Questions: Do the products of combustion weigh more than substances burned up?

PROJECT NO. 5.

Problem: To show that CO_2 is given off in the air from one's lungs.

Apparatus and material: A small glass, a glass tube, and lime water.

Directions: Fill a glass full of lime water and blow into it with a glass tube for one of two minutes and note what results.

Questions: Does this prove that the body gives off CO_2? Does this indicate that the body gives off something similar to a burning candle? What is the other name for CO_2?

Chapter II.

THE RESPIRATORY SYSTEM.

In our study so far we have considered the body as a mass of cells. We have learned how the individual cell consists of matter, how it depends on energy for carrying on, and how it releases energy by slow combustion. It is our purpose now to study the great systems that supply the cells with gaseous oxygen and food and that carry away the waste matters, gaseous CO_2, etc., that result from slow combustion in the body cells.

Before starting the study of the respiratory system it is well to point out that the human body is really one great whole, not a collection of parts—so many cells, hands, feet, eyes, ears, lungs, etc. For purposes of study, it is necessary to divide the body into parts and divisions, but often one can not fully understand one part of the body without knowing one or more other parts. As an example, we may take the respiratory and circulatory systems. As far as supplying oxygen and collecting CO_2, they are really one. The respiratory system delivers oxygen and collects CO_2 from the blood as it passes through the lungs, but that is only one part of the story, for the blood has to deliver oxygen to the cells and it has to collect and carry CO_2 to the lungs that it may be emptied into the air.

In our thinking it may help us to think of the respiratory system as external respiration and that part of the circulatory system that has to do with delivering oxygen and carrying away CO_2 from the body cells as internal respiration. In this chapter we will consider the respiratory system.

It is said that we live at the bottom of an ocean of air—a mixture of gases of which oxygen and nitrogen compose over 99 per cent. There is a small amount of CO_2: it is present in about 0.03 per cent. There is always more or less H_2O (water) dissolved in the air. There is also a small amount of dust particles. This ocean of air or gas extends upward for quite a distance. The distance has been estimated to be from 50 to 200 miles. The great bulk of the air is, however, within the first 5 or 6 miles. We have learned that air has weight. At the sea level 1 cubic foot weighs about 1.2 ounces. If one could weigh on the ocean's level a column of air 1 inch square, reaching as far as the air extends above the earth, he would find that it weighs about 14.7 pounds. The weight of the air causes it to press down and fill every space on the earth's surface that is not filled by other matter.

Project No. 6.

Problem: To show that air tries to fill space.

Apparatus and material: A glass of water and piece of cardboard.

Directions: (*a*) Fill a glass or a wide-necked bottle with water even with the top. Place a small piece of cardboard over the top

and, while holding it, invert the bottle or glass: then carefully remove the hand.

Questions: Does the water flow out? What holds the water in the glass?

Directions: (*b*) Fill a narrow necked bottle with water, invert, and note the time it takes to empty itself. Fill again and place a glass tube in the bottle.

Questions: Does it empty any faster? Why should the water flow out more readily? Can the water flow out without air coming in to take its place?

DEMONSTRATION NO. 4.

Problem: How to measure air pressure.

Apparatus and material: Barometer, a glass tube a yard long, a short U-shaped glass tube, same caliber, a short piece of rubber tubing inside diameter a tight fit over glass tube and a dish of mercury.

Directions: (*a*) Fill glass tube with mercury, cover open end with forefinger, and invert into a dish of mercury, remove finger and note the distance mercury falls. Measure the distance from the top of the column in the tube to the level of the mercury in the dish. (*b*) If a barometer is not available, carefully remove tube from the mercury, fill, and join the U-shaped tube and the yard tube by a piece of rubber tubing, cover open end, and replace in dish of mercury.

Questions: What holds up the column of mercury? Is its weight equal to the same sized column of air reaching to the surface of the ocean of air? Would it make any difference if the column was larger? If it were smaller? Mercury is 13.1 times heavier than water; would you expect that the air pressure would hold up a higher column of water? How high a column of water will be supported by air pressure?

ATMOSPHERIC PRESSURE.

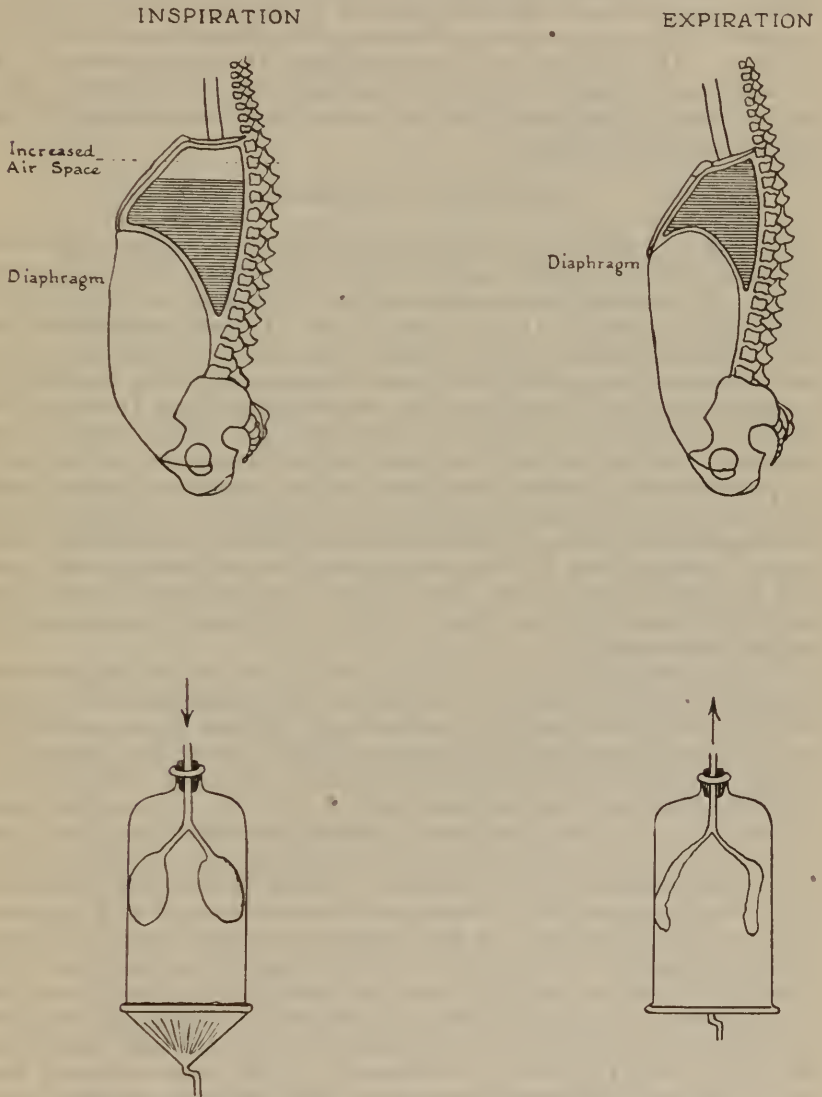
This attempt to fill space is spoken of as atmospheric pressure. It is called atmospheric pressure because the air surrounds the earth which is formed like a sphere. It is easy to understand atmospheric pressure when one thinks of it as the weight of the air pressing down from above. As one climbs a mountain, or goes up in a balloon, the pressure decreases, because there is less air from above pressing down.

The respiratory system has a twofold function. It must supply the body with its gaseous food, oxygen, and must rid the body of its gaseous waste, CO_2 (carbon dioxide). Usually we do not think of foods except as solids and liquids, but oxygen is really just as much a food as is any solid or liquid substance. The respiratory system consists of two parts, the framework of the chest and diaphragm; and second, all the internal organs, the lungs, trachea, and larynx and nasal passages connecting the lungs with the outer air.

LUNGS.

The lungs are composed, for the most part, of blood vessels and air tubes which end in small air sacs. The lungs' substance is composed of large amounts of elastic tissue which enables the lungs

to expand or decrease in size, and which permits them at all times to exactly fill the pleural cavity. The lungs of a new-born babe are pink in color, but the lungs of an adult who has lived in the city are very dark. In some cases they look almost black, due to the



An apparatus showing the effect of adhesions and the action of the diaphragm.

coal dust that has gotten into the lungs in spite of nature's efforts to keep it out. The lungs are light in weight and float high in water because of the large amount of air they contain. The lungs of animals are oftentimes referred to as "lights" because of their lightness in weight.

Pleural cavity.—The lungs move in a closed cavity or sac, called the pleural cavity. The lining of the sac and the covering of the lungs are composed of the same material. It is glistening and mirrorlike in appearance. When free from disease the lungs move freely with the least amount of friction, but in tuberculosis and other diseases, due to the development of pleurisy, that is, inflammation of this sac, portions of these surfaces become stuck or glued together. The pleural cavity is air-tight. It contains no air. It is really not a space but a cavity that in health is completely filled by the lungs. The lining of the cavity and the covering of the lungs come right together.

MECHANISM OF RESPIRATION.

The act of breathing or respiration is composed of two parts—inspiration and expiration. Inspiration is the entrance of air into the lungs. It is caused by muscular action. Expiration is the exit of air from the lungs. It is a passive act. During inspiration the chest is enlarged first by the organs of the abdomen, stomach, liver, and intestines being pulled down and compressed by the diaphragm, a large, fan-shaped muscle which separates the chest from the abdominal cavity, and secondly by the ribs being pulled upward and outward. In this manner the space in the chest cavity is increased and atmospheric pressure forces air into the lungs so that the lungs may continue to fill the pleural cavity. Expiration is caused (1) by the diaphragm releasing and allowing the contents of the abdominal cavity to expand and to decrease the space in the pleural cavity, and (2) by the falling of the ribs. These two conditions reduce the amount of space in the pleural cavity. The lungs become smaller as the air is exhaled.

Preparation of the air.—Few of us realize the careful adjustments that must go on in the nose and throat to prepare the air for the delicate and tender air cells in the lungs. Three things are necessary: First, the air must be freed and filtered from dust; second, it must be moistened; and, third, it must be warmed. The nose is well fitted for receiving the incoming air. At its entrance are many bristles or hairs which filter out the larger dust particles. The inner surface of the nose is lined by a mucous membrane which is covered by a sticky substance called "mucus." Under this mucous membrane is an erectile tissue that increases or decreases its size as it is necessary to adjust the area of the mucous membrane for moistening and warming the incoming air. The bones of the nose are very irregular in shape. By the irregular passages that they form, the direction of the air coming through the nose is constantly changed so that every air particle while passing through the nose must come in contact with the mucous membrane. It has been estimated that at least 1 pint of water is evaporated daily in the nose and throat, moistening the air that we breathe. On coming from a dry, warm atmosphere to one from 20 to 30 degrees colder and the reverse, the mucous membrane of the nose and throat is called upon to do what nature did not prepare it to do. The climate of the northern winters is not bad in itself; it is bad because few of us live in houses that are properly ventilated—the air is usually too warm and too dry. The mucous membrane of the nose and throat is not prepared to

stand the sudden changes of coming from outdoors to indoors and the reverse: as a consequence, the mucous membrance of the nose and throat becomes weakened; its vitality is lessened; it falls a prey to bacteria. Acute infection follows, one after another. These start as "colds in the head": they may spread to the throat, tonsils, larynx, etc. Not only do we suffer from these acute conditions, but there is a tendency for a chronic condition to develop which weakens the normal functions of the nose.

After passing through the nose and down to the back and base of the tongue, the passageway from the nose and mouth divide into two parts, namely, (1) windpipe (2) gullet. The air enters the windpipe: the solid and liquid foods enter the gullet or esophagus. The solids and liquids are prevented from entering the windpipe or trachea by the epiglottis, a trapdoor that covers over the top of the windpipe. When the food enters this part of the throat, the epiglottis closes down and the food glides over it into the gullet which lies just behind. Its action is reflex-automatic. It is a very faithful guard: it is always on duty. It is seldom, indeed, that food particles enter the windpipe, and when such an accident occurs the mucous membrane of the windpipe sets up a very painful sensation, compelling one to cough until the foreign body is expelled. The mucous membrane of the windpipe and air tubes bronchi is sensitive and has on its surface little whiplike bodies which keep whipping toward the mouth and carry along by this action mucus, sputum, dust particles, and little foreign bodies. The desire to cough is to get rid of these materials, but the act of coughing should be suppressed until the mucus is high in the throat and can be expelled with little effort. At the top of the windpipe is found the larynx. In pulmonary tuberculosis the larynx is often infected. It is thought that tuberculosis of the larynx may result from injuries caused by coughing, tubercle bacilli in the sputum passing over the injured areas enter and infect the tissues below. The symptoms vary from a slight hoarseness or huskiness of the voice to, in some cases, tuberculosis of the larynx: talking and the act of coughing should be reduced to a minimum. Rest is very essential here as in other forms of tuberculosis. Shortly after passing the larynx the windpipe divides into two branches, one of which goes to each lung. These branches are called "bronchi" and keep dividing up like the branches of a tree until at last the smallest branch ends in a little sac which corresponds to the leaves of a tree. In the air sacs the air is separated from the blood by just the thinnest wall. The average person is said to have 2,000 square feet of this thin wall space between the air in the air sacs and blood in the blood vessels. Through this wall the oxygen from the air passes into the blood and the CO_2 from the blood passes into the air in the air sacs. We do not know just what causes these changes. It may be a specific function of the cells of the air sacs, or it may be a simple diffusion of gases, or a combination of the two.

VENTILATION OF THE LUNGS.

The rate and control of pulmonary ventilation.—The rate of pulmonary ventilation depends partly upon the oxygen needs of the body, but mostly upon the necessity of the body cells to be rid of

their poisonous waste, CO_2. The nervous centers that control respiration are very readily affected by an increase of CO_2 in the circulating blood, and normally exercise a very rapid and efficient control of pulmonary ventilation. As soon as one starts to do work the ventilation of the lungs increases rapidly and at the end of three minutes reaches an average of 35.6 pints (20 liters) per minute. In work that is moderate and suited to the person there is established a constant ventilation of the lungs; with the development of fatigue the respiratory rate at first decreases and then becomes irregular with an increase in rate. Normally, the length of expiration is nearly twice that of inspiration, but in fatigue the period of expiration is shortened and the ventilation of the lungs suffers, because time is needed for the oxygen to pass in and the CO_2 out. This failure of the respiratory function causes an increase of CO_2 in the blood. The nervous system especially is greatly affected by an increase of CO_2 in the blood. The system loses its power and one is compelled to rest.

By measuring the amount of oxygen used in excessive fatigue, Professor Amar, a leading French physiologist, has found that more oxygen is used to do the same amount of work. In other words, as fatigue increases the human machine does poorer and poorer work; it becomes less and less efficient; it wastes energy. Amar has observed a greater efficiency and economy in the amount of oxygen used when effort and pace were moderated so that the work was accomplished without great fatigue. From a practical point of view, Amar says that the rate of movement should not be fast enough to produce breathlessness (a cause of prompt fatigue); second, the force used should not be great enough to interfere with expiration; and, third, the clothing must allow the free action of the chest and abdomen. He adds, as has been noted above, that irregularity of respiration is the first indication of fatigue.

In the boat races on Lake Como, in Italy, Mosso, the noted Italian physiologist, carefully observed the crews for signs of fatigue. He reported that in the oarsmen exercised beyond capacity that at first the respiration became irregular and very rapid; finally they became so breathless that they were unable to continue the race.

VITAL CAPACITY OF THE LUNGS.

Indirectly, the ability to do physical work depends upon the vital capacity of the lungs. The vital capacity is an index of what the lungs can do. It is the total amount of air that can be breathed in and out at one time. To determine the vital capacity a person is instructed to breathe in as much as possible and then the amount of air he can breathe out is measured in a machine called a spirometer. In disease, as pulmonary tuberculosis, acidosis, heart disease, etc., the vital capacity is decreased. In pulmonary tuberculosis the vital capacity is reduced by an actual destruction of lung tissue. In severe cases only a small portion of one lung may remain. This loss of lung tissue acts as a mechanical disability. It interferes with one's ability to labor just as would the loss of a hand or arm; just as the blacksmith depends upon his bellows for supplying his furnace with oxygen, so the working man depends upon his lungs to furnish oxygen in order that his muscle cells may release the energy necessary to do his daily work.

INJURIES TO THE LUNGS.

Air may enter the pleural cavity between the lungs and the chest wall by either of two ways—puncturing wounds of the chest wall, or by breaking down of parts of the lung tissue, allowing the escape of air. Wounds of the chest wall are uncommon, but in tuberculosis the escape of air into the pleural cavity by a breaking down of lung tissue is common. When this accident happens, the lung on that side collapses and is unable to expand until the opening is closed and the air absorbed. This condition is called spontaneous pneumothorax. If it were not for pleurisy, pneumothorax would more often result fatally. Pleurisy is common in tuberculosis; it results in the pleural surfaces becoming glued together. This gluing together of the pleural surfaces is found practically always over the diseased parts of the lungs, and so prevents large pneumothoraces. Breathing exercises are useful to increase vital capacity; but in tuberculosis, even though the disease is inactive, one should not practice breathing exercises except on the advice of a physician for at least two or three years after arrest of the disease, for until then there is still danger of breaking the scar tissue that is seeking to wall off the tuberculous area.

ARTIFICIAL PNEUMOTHORAX.

Some few cases of pulmonary tuberculosis are suited to a form of treatment based on this property—that when air enters the pleural cavity it collapses the lung. When the disease is confined largely to one side, with little or no disease on the opposite side, and if there are no adhesions on the diseased side, artificial pneumothorax may be indicated. This treatment is performed by the simple operation of puncturing with a large needle the chest wall into the pleural cavity. Through this needle a measured amount of air is allowed to enter. The gas causes the diseased area of the lung to collapse. Refills are necessary, because the air is slowly absorbed by the pleural surfaces, and the collapse must be kept up. This form of treatment is useful in quite a portion of cases. It depends for its benefit on the local rest to the diseased areas of the lung. The treatment is continued for several months, and sometimes longer.

COMPOSITION OF THE INSPIRED AIR.

The composition of outside air varies but little in the different parts of the earth. There is 79 per cent of nitrogen and nearly 21 per cent of oxygen. There is about 0.04 per cent of CO_2 and a trace of many other gases. In addition to this mixture of gases, air contains dust particles and water vapor in solution. In the region of cities there is a slightly greater proportion of CO_2; for, as we have learned, in the country vegetation—plants and trees—takes up, breathes in, as it were, CO_2 and gives out, or breathes out, as it were, oxygen. The slight increase of CO_2 in the cities is not of any practical importance from the health standpoint.

COMPOSITION OF EXPIRED AIR.

The amount of CO_2 in expired air is very much greater than that of inspired air. There is approximately 100 times as much CO_2

in the air breathed out as in the air taken in. The increase of CO_2 is at the expense of the oxygen. The inspired air contains nearly 21 per cent and the expired air nearly 16 per cent oxygen.

	Oxygen.	Nitrogen.	Carbon dioxide (CO_2).
	Per cent.	*Per cent.*	*Per cent.*
Inspired air	20.96	79	0.04
Expired air	16.02	79	4.10
	4.94	....	4.06

This table shows that more oxygen (O) is absorbed than CO_2 given off. It is characteristic of carbohydrates that in their combustion the same amount of CO_2 is given off as oxygen consumed. A study of the formula of the carbohydrates, as, for instance, sugar, which we studied while considering the yeast plant, show why this is so. There is just sufficient oxygen in the carbohydrates to unite with all the hydrogen (H). The gaseous oxygen, therefore, is used to unite with the carbon (C), and for this reason as much CO_2 is given off as oxygen absorbed. With the proteins it is different. Some of the oxygen is used to unite with sulphur (S) and hydrogen (H.) On the average, for every 100 cubic centimeters of oxygen absorbed there are 85 cubic centimeters of CO_2 eliminated in the lungs.

The daily amount of oxygen.—A man weighing 70 kilos (154 pounds) breathes about 11,000 liters or (440 cubic feet) of air in 24 hours. About 428 liters of CO_2 are eliminated in 24 hours. This means that about 500 liters of oxygen are absorbed, which is about the amount of oxygen found in 100 cubic feet of air.

Ventilation.—The amount of CO_2 in the air is readily determined. For this reason it has been used as a measuring stick for determining the purity of air. It has been taught that air containing over 0.06 per cent is impure and should be purified by ventilation. According to this rule, about 3,000 cubic feet of fresh air are needed every hour. This fresh air may be supplied continuously or at intervals. It has been found recently that the amount of oxygen and CO_2 in the air are not as important as the temperature and the humidity. For this reason a study of ventilation is more concerned with these items than it is with the chemical composition—the amounts of oxygen and CO_2.

PHYSICAL PROPERTIES—CHARACTERISTICS OF GASES.

Besides having weight and taking up space, gases have several definite physical properties. Gases resemble liquids: (1) They flow or run; (2) they dissolve certain substances just as liquids do; (3) they expand on heating and contract on cooling; and (4) they very readily mix or diffuse, as it is called.

Gases are said to flow or run. A south wind is air flowing toward the north. A heavy gas like CO_2 runs down hill; on the other hand, a light gas like hydrogen flows up.

Gases dissolve liquids; for example, the air dissolves water. The amount of water the air can dissolve depends upon the tem-

perature (just as warm water can dissolve more salt than cold water). The warmer the air the more water it can dissolve and hold in solution. The amount of water in the air is measured by the wet-bulb thermometer. The wet-bulb thermometer does not give one the actual amount of water in solution, but the percentage of water present. One wishes to know the degree of dryness or dampness of the air rather than the actual amount of water present. For this reason the readings from the wet-bulb thermometer are given in terms of relative humidity, which is the same as relative dampness or dryness. For example, a relative humidity of 80 means that the air contains 80 per cent of all the water it can dissolve at that temperature.

Gases expand on being heated, just as most liquids do; that is, they take up more space for the same amount of weight. Because air expands when heated, it becomes lighter and rises. One may say that the warm air is really forced up by the cooler and heavier air about it, just as a piece of wood is forced to the top of water because per cubic foot the wood is lighter than the water.

And lastly, gases readily mix or diffuse; for example, if a jar of hydrogen is placed neck to neck over a bottle of oxygen, in spite of the fact that the hydrogen only weighs about one-sixteenth as much as the oxygen, in a short time hydrogen will be found in the lower jar and oxygen in the upper one. This property of gases is so strong that everywhere on the earth's surface the amount of oxygen in the air is practically the same.

Demonstration No. 5: To show that a heavy gas like CO_2 runs down hill.

Project No. 7: To show that air expands when heated and contracts when cooled.

Project No. 8: To show that air contains water in solution.

Project No. 9: To show that wood floats because it is lighter than water.

Demonstration No. 6: To set off a hot-air balloon.

Demonstration No. 7: How to read a wet-bulb thermometer.

Demonstration No. 8: To show the action of the diaphragm and the affect of adhesions.

Chapter III.

CIRCULATORY SYSTEM.

CIRCULATION OF THE BLOOD.

In 1621 William Harvey, an English physician, discovered the circulation of the blood. Until that time it was not known that the blood traveled from the heart to all parts of the body and back again; that it left by way of the arteries and returned by way of the veins. The arteries had been thought to be air tubes and the blood in the veins had been thought to run back and forth like the ebb and flow of the tide. The discovery of the circulation of the blood was a great step forward in the study of the human machine, for until then any real progress in the study of physiology was impossible.

The ancients thought of the blood as the seat of life. In this respect their ideas were quite right, for so dependent are the cells on the blood and the body on its cells that when the blood stops flowing life comes to a sudden end. If one injects air into one of the large veins of a rabbit's ear, in a short time the rabbit stiffens out, has a spasm, and within a very few seconds dies. On opening the heart the air is found collected within the heart. The air prevented the blood from passing through the heart. When the blood stopped circulating, the rabbit died. In their specialization and division of labor the cells of the body have become most proficient and skilled; but in proportion as they have become proficient and skillful they have become dependent on each other. This dependence applies especially to the blood stream. The body cells have become used to the blood delivering at their door supplies, digested food and oxygen, that they need for combustion. They are in the habit of dumping their waste products resulting from slow combustion into the blood to be carried away. The cells can not live without energy; they can not live with their poisonous waste matters. When the blood ceases to flow, the supplies of food stop and the collection of waste matters cease, so the cells and the body in which they live speedily die.

THE HEART.

The circulatory system is composed of the heart, arteries, veins, and blood. It is a closed system. The heart is the center of the system. It should be thought of as a double force pump—two pumps joined together side by side. Each pump is divided into two parts, an antechamber and a chamber. The antechambers receive the blood during the resting periods of the heart. They then force the blood into the chambers, and the chambers by their muscular walls force the blood from the right pump of the heart to the lungs and back

again, from the left pump of the heart to the whole body and back. As the left pump has the greater amount of work to do it is much larger. At the exit of each chamber and antechamber there are valves which prevent the blood from flowing back, once it has passed through.

Location of heart.—The heart lies between the right and left lung just behind the breastbone. It is located a little to the left of the center. In health one seldom notices the action of his heart. However, if one will feel below the fifth rib about 2 inches from the breastbone he can usually feel the beat of his heart, for the lower end of the heart touches the chest cage at this point. On severe exercise one may become conscious of his heart action because it beats more rapidly and more forcibly.

Defect of the heart valve.—In certain infections, like rheumatic fever, tonsillitis, and pneumonia especially, the heart valves may become affected and lose their ability to close tightly. They may become leaky and allow a backward flow of some of the blood, or the parts of the valves may become stuck or glued together so that they can not open wide to allow the easy onward flow of the blood through them. Sometimes these defects are combined so that a valve may leak as well as obstruct the onward flow of blood. In either case the defect may be great or small. Where the defect is small it has been found within 30 days that the heart is able to enlarge enough to make up for the leak or obstruction. The power of adjustment of the heart is very great. It is one of the marvels of nature. The size of the heart varies with the amount of work that it has to do. The heart of the race horse is much larger in proportion than that of the work horse. It is said that the heart of a deer is twice as large in proportion as that of a sheep. It has been estimated that the heart of the average individual does 124 foot-tons; that is, as much work in 24 hours as would raise 124 tons 1 foot high. This may be put in another way, as follows: It will raise the body of an average person a distance of 1,000 feet.

CONTROL OF THE CIRCULATION.

The heart pumps the blood against a certain amount of pressure or head, as it is called in speaking of liquids. In large cities the water supply is often arranged so that the water pressure can be increased in any of the several areas of the city. This is usually done by cutting off the water supply from other areas. The same thing is done in the circulatory system. When more blood is needed in any part of the body, as, for example, during digestion or active exercise, part of the supply is cut off from the other organs of the body. Action in any part of the body calls for an increased amount of blood. The amount of blood in the circulation is of course limited. For this reason it is best not to take any very active exercise shortly after eating.

ARTERIES.

The blood leaves the heart in two great arteries—one leading to the lungs, the other to all parts of the body. The arteries divide until at last they end in the smallest of vessels, capillaries, which

are so fine that they can not be seen with the naked eye. The other ends of the capillaries are joined to the veins. The flow of the blood is continuous from the arteries to the veins through the capillaries, which are one-twentieth the size of a fine hair. In the arteries the blood flows in spurts or jets, one for every beat of the heart. Rate of the pulse varies for the different positions of the body. When lying, the average rate is 64; sitting, 68; and standing, 76. The reason for this is evident—more work is required to pump blood through the body in the erect position than while lying down.

Veins.—The blood returns to the heart by way of the veins and it flows in a stream. The flow of blood in the veins is pressed forward mostly by the heart, partly by muscle action, for the veins contain valves which allow the blood to flow only forward toward the heart. Besides this, during inspiration the negative pressure in the chest increases the flow of blood to the heart.

THE BLOOD.

The blood has been called a circulating tissue. It is estimated that the total amount of blood in a person is equal to about one-twentieth of his weight. Blood is composed of liquid and solid parts. The color of the blood varies from a scarlet to a dark bluish red. The shade depends on the amount of oxygen carried by the red blood cells. Blood has a salty taste and gives off a faint odor. It is a sticky fluid, a little heavier than water, and during health its composition remains almost exactly the same. The blood flows under a certain pressure. This blood pressure is greatest during the contractions of the heart. The blood is forced out of the heart into the arteries. The large arteries act as an elastic bag. The pressure is continued from one contraction or beat of the heart to another by this elastic pressure in the arteries. The arteries expand like rubber, blood is forced forward (the heart valve keeps it from going back), and before the pressure falls too low another contraction of the heart raises it again. In taking the blood pressure the average highest and lowest points are taken. Blood flows very rapidly in the arteries, very slow in the capillaries, and faster again in the veins but not as fast in the arteries. Experiments have shown that the blood flows through the body and back again in about 23 seconds.

Plasma.—The liquid part of the blood is called plasma. It is yellowish-green or straw colored. Plasma serves as a medium for carrying the solid parts of the blood. It carries away part of the CO_2 from the cells and brings them liquid nourishment. Plasma is an important factor in the coagulation (clotting) of the blood. When blood escapes from a blood vessel there is developed in the plasma, because of injury to the blood cells, small hair-like branches which run in every direction. These branches cause the blood to become solid. If it were not for this special property of the blood even a small cut would have a tendency to result seriously. In the capillaries part of the blood plasma leaks out between the cells into the watery substance surrounding the body cells.

Lymph.—The body cells are really water animals. They are surrounded by a watery substance called lymph. Lymph is diluted blood plasma. The lymph is more watery than the blood, so that the osmotic pressure may attract and draw from the blood the digested

food. In this way the lymph serves as a middleman or, as one may say, a transfer agency. It transfers from the blood to the cells oxygen and digested food. It is also able to transfer CO_2 into the blood, as the blood contains less CO_2 than the lymph. None of the lymph flows back into the capillaries. Part of it flows back to the heart by way of the lymphatic channels or vessels which follow the veins and finally empty into one of the large veins near the heart. The amount of lymph is dependent on the heart action and other conditions that are not very well known. It is known, however, that in heart disease it is common for the lymph spaces surrounding the cells in the lower limbs to become greatly filled so that the limb swells. This condition, often called "dropsy," may be a sign of chronic heart disease. It is usually associated with disease of the kidneys, for, as we shall learn, the amount of water in the body, especially in the lymph and plasma, is dependent on the kidneys. In hemorrhage the lymph is used to replace the liquid part of the blood.

The solid parts of the blood.—The solid parts of the blood are composed of red blood cells, white blood cells, and some small particles. It is said that the solid parts of the blood compose about a little more than one-half of the liquid parts.

The red blood cells.—The red blood cells compose the greater part of the solids of the blood. They average 5,000,000 to a cubic millimeter. There are more in man than in woman. Red blood cells are shaped like a flat disk. On end they appear like a dumbbell. The cells are elastic and so are able to go through capillaries that are smaller than the cells themselves. The main function of the red blood cells is to carry oxygen from the lungs to the body cells. They are able to do this because they contain a substance called hemoglobin, a protein containing iron. This iron protein enables the blood to carry about 25 times as much as can be carried by the liquid part of the blood. The red blood cells are made in the red marrow of the bone. Like most body functions, the capacity of the red blood marrow may be greatly increased so that in hemorrhage the loss in red blood cells may be more rapidly increased. It takes, however, on an average of from three to four weeks to completely replace the red blood cells lost in a severe hemorrhage. The red blood cells are continually being worn out and replaced. It is believed that they live from four to six weeks. When they become worn out and no longer useful they are taken up and destroyed in the liver.

White cells.—White blood cells are much fewer. They average about 8,000 per cubic millimeter. The white cells can move and in some conditions—injury and disease—are able to pass through the walls of the capillaries. This the red cell can not do. The white cells have been called the policemen and scavengers of the blood. They are able to take up bacteria and foreign materials and destroy them. In certain infections, especially pus infections like the familiar boil in the skin, they are found in great numbers. Pus from a boil or abscess is really a collection of injured and dead white cells. They are really battle casualties. Their presence in large numbers is evidence that the body is making an effort to destroy the germs. Later, under the study of immunity, we will take up how the body defends itself.

FATIGUE.

Heart rate as an indication of fatigue.—The heart is very responsive to the various calls of the body. Their S O S calls are promptly answered, and the amount of blood sent to each part of the body is increased or decreased, according to the demands. It has been found that exercise or work that is not too severe may increase the rate of the heart beats up to about 120 beats per minute. Work that causes the heart to beat faster than this (130 and over) is not hygienic and should be avoided. Work that causes the pulse to reach about 115 to 120 beats per minute if continued without rest periods results in a decrease to 100 or even 96 beats per minute as fatigue develops. This decrease in rate results from an overworked heart. The heart is not able to supply the needs of the muscles. Rest or a slower pace is needed to enable the heart to catch up with the needs of the cells that are in action. If not heeded, the heart becomes rapid and weaker. The heart, while it is a wonderful pump, has a limit to its capacity. When pressed to do more than it is able to do, the heart works to the limit, for it is not a quitter. Its increase in rate is an urgent sign of overloading; it is a signal of danger. The pace must be slackened to allow the heart to rest; to continue means heart bankruptcy.

When the heart rests.—It should be noted in passing that even the heart has its rest periods. Between every beat there is a period of inactivity. Normally, the heart rests more than it works. When the heart is beating at the rate of 72 times per minute, the muscles of the heart are in action for 0.3 of a second. They have a rest period of 0.5; or, to put it on a 24-hour basis, the heart muscle works 9 hours and rests 15. When the heart beats faster, it is at the expense largely of its resting period. This fact makes it clear that one should not attempt to do work that increases the heart rate too greatly, for to do so shortens the rest periods. The heart cells are supplied with nourishment during the rest periods. When the rest periods are short, the cells are only partly nourished and must use up their reserve.

The nervous control of the heart.—We have not studied the nervous system, so it is more difficult to understand the nervous control of the heart. It will become clear, however, after we have studied the nervous system. The heart contains muscle cells that are unusually susceptible to nervous control. The heart muscle of certain of the lower animals will beat for hours after it has been removed from the body of the animal. Besides the special groups of nerve cells called ganglia, there are two groups of nerves leading to the heart. One group increases its rate, the other slows it. This nerve control causes a very economic adjustment of the heart to its work. Under normal conditions the heart action is in direct proportion to the requirements of the body cells for supplies of food and oxygen and for disposal of CO_2 and other wastes.

Sir James MacKenzie, the greatest heart specialist of to-day, gives very practical advice on how a person suffering from heart disease should carry on. It is his opinion that the patient can govern his exercise by his sensations. He says the heart function is a variable; that it has its off days when it can not do so well. It is impossible for the physician to say exactly how much the patient can do on any

one day. The condition of the digestive system, loss of sleep, and even the weather have their influences. He sets up this guide: The patient can exercise as long as he does not develop any distressing sensations. It is necessary for him to stop as soon as his exercise causes him distress.

Some years ago there lived in New York a famous athlete and physical trainer. Later he established a most successful health resort. He had never studied medicine, but his ring experience had taught him to measure physical capacity. He was not able to examine a heart, but he had discovered what Sir James MacKenzie was proving, that the correct way to determine the condition of a heart is by its response (reaction) to work or exercise, rather than to depend on examination alone. It is said that when a new case was admitted to his health resort he would run this person rapidly up a flight of stairs. If the patient's pulse did not fall within a minute and a half, he would give him very light exercise. On the other hand, if the pulse rate fell to normal, the case was put on active labor. He was a real slave driver and by his tongue and strong arm he kept his patients at work sawing wood, hiking, riding, etc. He made his patients work themselves well. It should be noted, however, that these cases were not ill from bacterial diseases but from improper habits of living. The majority were suffering from overeating and insufficient physical exercise.

CHAPTER IV.

THE DIGESTIVE SYSTEM.

FUNCTION.

Life is activity. Activity requires energy and it wears out or uses up parts of the body. Energy, repairs, and replacements (new parts) come to the body stored up in food.

In the body cells the C and H of the foods are united with the gaseous O from the air to free the energy needed for (1) emotion and power (2) for heat, and (3) for carrying on the internal workings of the body. Besides the nitrogen, sulphur and iron of the food are used to repair worn-out parts and make replacements. Food is absolutely necessary for life. It has truly been said we eat to live, but until the food is digested and carried by the blood stream to the cells it is of no use. Digestion is the preparation of foods so that they may be taken in the blood. Digestion is the first step in supplying the body cells with the means for living.

All animal life is dependent on its supplies of food. Much of the battle of life consists in getting food. The animal can not produce more energy than is contained in its food. Lack of food means lack of energy, and lack of energy means death. The body cells must be supplied with food—energy and repairs—if they are to live and do their bit for the cell community.

The function of the digestive system is to dissolve the foodstuffs so that they may be filtered through the lining or wall of the digestive tract and taken up by the blood stream. Until the food starts filtering its way through the walls of the digestive tract it is not a part of the body. In short, the digestive system must be thought of as a small factory where foods are ground, mixed, and changed by chemical action into such a condition that they may be filtered through the lining of the intestines into the blood.

Digestion is one of the five special functions of living cells. In the one-celled animals these properties are equally developed. A division of labor is impossible. In the many-celled animals, as we have learned, there can be a division of labor. Groups of cells can take special jobs. Because they are able to devote all their time to one job they become efficient. The digestive system is an example of a group of cells that has been set apart to do one of the five functions, namely, to prepare and digest the food for all the other body cells.

The function of the digestive system is to break up and dissolve the food for the body. It acts mechanically and chemically; for example, the teeth prepare the food by grinding and crushing, but the most essential change in the food is brought about by the digestive juices through the action of their ferments. The power of the

ferment of the digestive juices lies in their ability to add water and, by so doing, are able to divide or split up the food into smaller parts that are soluble.

The digestive system is composed of the mouth, teeth, gullet, stomach, small and large intestines, as well as the liver and pancreas.

The mouth.—The mouth is at the entrance of the digestive system. In it the food is ground up by the teeth and moistened by the saliva. Saliva is a body juice secreted by glands located in the cheeks and under the tongue. The saliva contains ptyalin, which starts the digestion of the starches. When the food is well chewed, it is swallowed unconsciously and is carried very rapidly through the gullet into the stomach. The saliva of the mouth is neutral in reaction and continues its action on the starches in the stomach until digestive juices of the stomach, which are acid, change the reaction of the food to acid.

The stomach.—The stomach is a muscular organ. It is composed really of two parts or divisions. The first part, where the food enters, acts as a storehouse. The second part, the part connected with the intestines, acts more as a churn, for there the foods are mixed until they become creamylike and are ready to pass into the small intestines through the pyloric gland. The juices of the stomach act only on the proteins; they do not act on the starches. The stomach's action on the food not only starts the digestion of the proteins, but it also acts as a sterilizer or disinfectant. The carbohydrates, especially the sugars, begin to pass through the stomach very shortly after eaten. The protein food remains longer. The fats are the last to pass. When all three kinds are eaten, the carbohydrates do not begin to pass into the intestines as early. In a similar manner the proteins are delayed. The stomach should empty itself in from one to four hours. If food is found in the stomach after this time there is definite disease, usually some mechanical condition that prevents the food from passing through.

INFLUENCE OF MENTAL STATE ON DIGESTION.

The X-ray has greatly enlarged our knowledge of the digestive tract. By mixing bismuth with food the outline and action of the stomach and intestines are readily observed. Some years ago Doctor Cannon, of Harvard University, studied digestion in the stomachs of cats. He discovered some interesting facts. He found that there are two divisions, as has been noted before, and that there are waves or contractions in the stomach wall, passing from the gullet end of the stomach to the pyloric end. In that part of the stomach next to the pyloric valve the waves are especially strong and more active. He found that they come regularly and every few seconds. Their purpose is to mix and churn up the food and carry it forward. When the food becomes well mixed and liquid, the pyloric valve opens and allows it to pass in small jets from time to time into the small intestine. In one test there was added a small indigestible piece of bismuth, covered with starch, to the food fed to the cat. The piece was seen many times to come up to the pyloric valve, but it was rejected every time until 42 minutes had passed. At last the pylorus gave up and allowed the piece to pass through. This observation shows the necessity for the careful

chewing of food into a fine mass. One day Doctor Cannon happened on an unfriendly cat. Soon after the X-ray observations were started the cat became ill at ease and angry. An interesting fact was found, namely, that the waves noted in the other cats were not present; that there was no motion in the stomach wall.

Anger stops digestion.—To further prove this fact, that anger stops digestion, a friendly cat was irritated, and again it was noted that there were no waves in the stomach wall. But as soon as the cat was petted and began to purr, the waves started up once more. These facts prove that a happy frame of mind is important for a good digestion.

Appetite juice.—Some years ago Pavlow, a Russian physiologist, performed some very interesting experiments on dogs. He divided their gullets so that the food eaten by a dog could be made to enter the stomach or pass out in a tube. He also made an opening in the wall of the stomach so that food could be placed directly in the stomach without being eaten, and so that he could watch what was going on in the stomach of the dog. He found that when food that was pleasing to the dog was held before him that the juices in the stomach started to flow within five minutes and continued for a time. although the dog was not given any of the food to eat. The same thing happened when the food eaten by the dog was diverted to the outside so that it did not reach his stomach. The gastric juices continued to flow. On the other hand, it was found that food placed directly in the dog's stomach remained for hours without exciting any flow of gastric juices. Doctor Beaumont did some similar experiments on Alexis St. Martin, a Canadian trapper, who had an opening in his stomach, the result of a gunshot wound. Doctor Beaumont found that taste had a marvelous effect on Alexis's digestion. When Alexis ate food that was pleasing more gastric juice would pour out into the stomach than when he ate food that he did not like.

Pavlow found that when a dog drank a pint of water a liberal flow of gastric juice was poured out, but that if a grain of soda were added to the water no juice was poured out. This would indicate that biscuits, cakes, and such foods prepared from baking powder, soda, and cream of tartar will have a tendency to delay digestion by interfering with the flow of gastric juices. Vinegar is found to have a similar effect on the saliva. In equal amounts, vinegar is more poisonous than alcohol. Where possible, lemon juice should be used to take the place of vinegar as in salads, etc.

A German chemist observed in experiments upon a dog that a solution containing only 6 per cent of cane sugar caused irritation with reddening of the mucous membrane lining of the stomach. A 10 per cent solution produced a dark-red color, with great irritation, and caused the animal great pain. You can appreciate that sugar should not be taken alone into an empty stomach. Taken in small quantities in connection with the meals it will probably do no harm to a healthy person. (Kellogg.)

INTESTINAL DIGESTION.

After the food leaves the stomach it passes into the upper part of the small intestine. Here the acid reaction from the gastric juice is turned alkaline by the juices from the pancreas and the bile

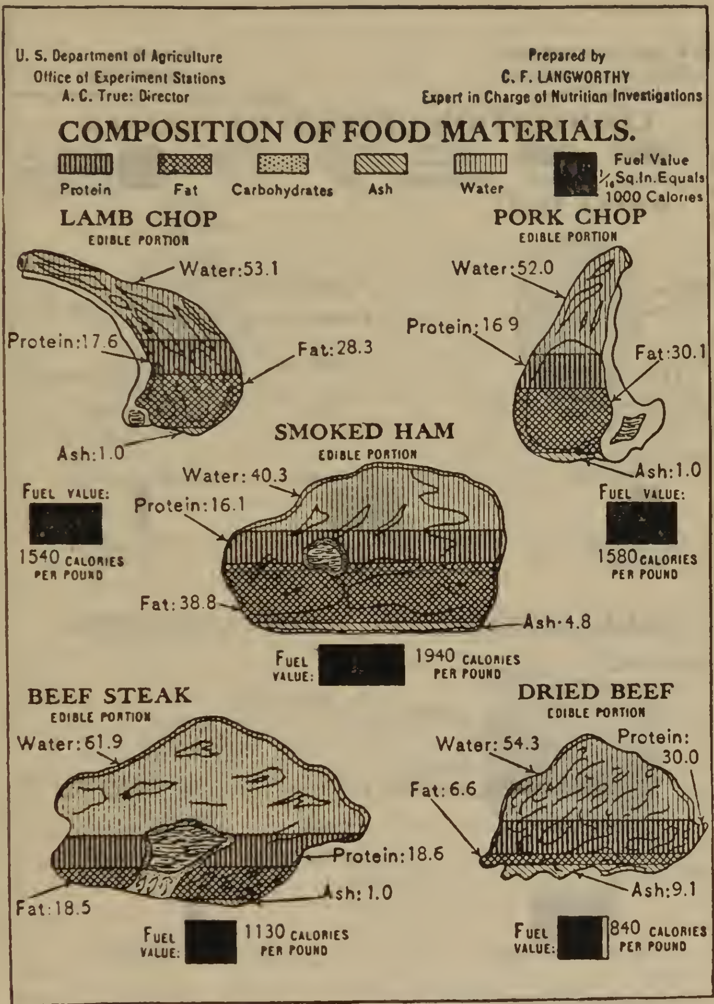
from the liver. The pancreatic juices contain several powerful ferments which act on, break up, and digest all the different kinds of foodstuffs. The bile helps in digestion, especially in the breaking up of the fats. Experimental feeding on dogs has shown that the pancreatic juices adapt themselves to the kind of food eaten; that is, when there is an excess of protein food the ferments that digest protein are greatly increased. These facts indicate that our digestion is better when we eat the same kind of foods and that too great a variety in the diet is not good. The digestion is practically completed in the small intestine. The contractions, the waves (called peristaltic waves), noted in the stomach are also found in the intestines. They serve to force the food forward and aid in digestion. Normally, these waves are not felt, but, as in disorders (as any boy who has eaten too many green apples can testify), these waves may become very painful. They are then called "cramps." From the small intestine the food passes into the large intestine, where more of it is absorbed, water is taken out, and the remainder, which is not only of no use, but is really like so much dead material, needs to be regularly disposed of. Doctor Beaumont found that bulk helps to aid intestinal digestion and prevents constipation. Fruits and vegetables are useful for this purpose—that is, getting rid of the waste.

In a healthy state the digestive system works with order and in harmony with the rest of the body. If one will eat a simple, well-balanced ration with sufficient vitamin; if he will eat slowly, in moderation, and at regular intervals and with mirth and laughter as companions, he will do his part to keep his digestion in a healthy state. It is worth while to seek favor with the digestive system, for one's digestive system is his best friend, especially is this true of an arrested T. B. case. Once impaired, your digestive system becomes temperamental. It sulks and it may even go on strike. Do not abuse it by eating at any and all times, by eating lots of candy, and by delaying stomach digestion by eating quantities of ice cream at the end of a meal. Do not overeat and do not eat as though going to a fire.

FOODS AND THEIR USES.

What to eat and how much.—Very few persons know what to eat or how much to eat of the different kinds of food. Cost and taste too often decide the choice of foods, while appetite determines the amount of food. These are not reliable guides. Improper habits in eating are not only handicapping persons in their life's work and recreation, but are shortening their life itself. Many are dying at from 50 to 60 years of age that should live from 65 to 75 years. Knowledge of what to eat and how much, expressed into proper food habits, would help in lengthening the human life. The human motor is a valuable machine. Its efficiency depends upon what it is fed. It needs carbohydrates and fats for energy. It needs a small amount of protein, vitamines, mineral salts, and acids for body building and regulating—that is, for repairs and upkeep. Besides, it needs water in large amounts, for water enters into the substance of all parts of the body and is used in all the vital processes or functions.

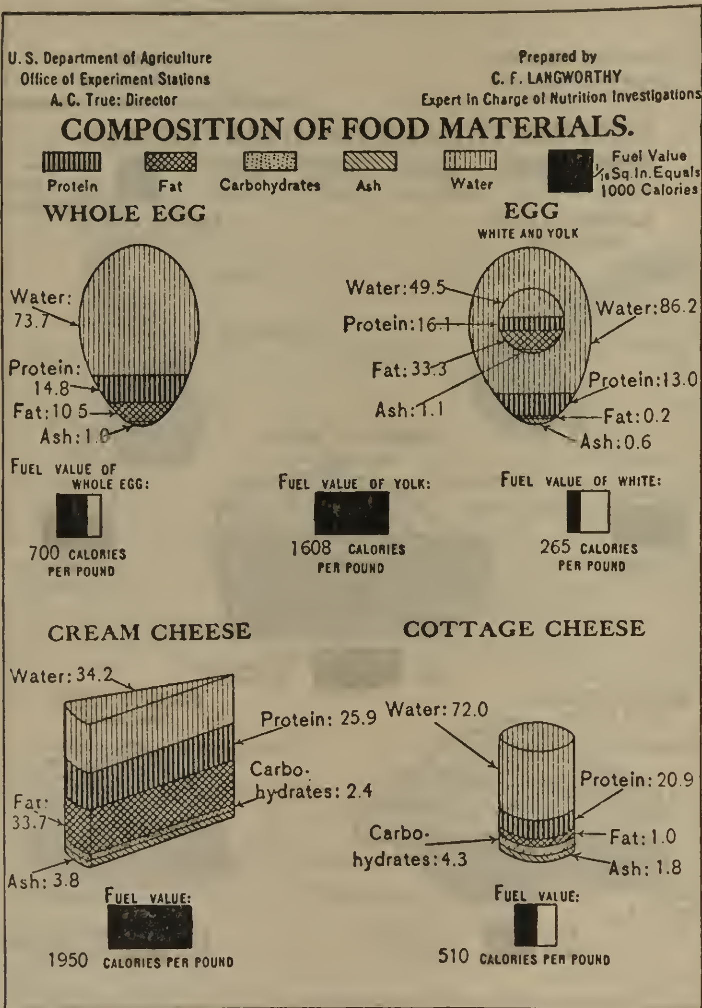
Proteins.—The proteins are the most important and expensive group of foods. They are composed of carbon, hydrogen, oxygen, and nitrogen, and may contain also small amounts of sulphur or phosphorus. Proteins are found principally in meats, eggs, beans and peas, and dairy products, such as milk and cheese. They are also found in lesser amounts in cereals, as wheat, corn, oats, etc. In the child proteins are used in the body for building—that is, for



growth. In the adult they are used for repairing—that is, in replacing the worn-out parts of the body cells. Protein may be used to supply energy, but this use is wasteful. For example, it has been found that a dog fed on proteins alone uses up 40 per cent more food than when fed on a mixed diet. Besides, the use of protein in this way is harmful as well as wasteful, for in the combustion of the protein not only do the usual products of combustion, CO_2 and H_2O,

result, but in addition there are other wastes that, until they are eliminated, act as poisons.

Carbohydrates.—Carbohydrates are the great suppliers of energy. They are composed of carbon, hydrogen, and oxygen. They are the cheapest of foods and should supply most of the energy of one's diet. Carbohydrates are better known as starches and sugars; foods like potatoes and rice are composed largely of starch. The cereals—



wheat, corn, etc.—contain large amounts of starch, but in addition they contain considerable amounts of protein. Of the sugars, cane and beet sugar are good examples, as well as the sugar in fruits—grapes, raisins, oranges, etc. Carbohydrates are burned in the body cells and turned to water, H_2O, and carbon dioxide, CO_2. These wastes are easily gotten rid of; the water is taken up by the blood, and the CO_2 is excreted—given off by the lungs.

Fats.—The fats, like the carbohydrates, are composed of carbon, hydrogen, and oxygen, but there is only one-half as much oxygen. For this reason the fats take up more of the gaseous oxygen, and so release more energy in the body cells. For this reason fats supply twice as much energy per pound. They are burned up like the carbohydrates to H_2O and CO_2, but they are more difficult to digest, and except in cold weather the amount of fat eaten is usually not greater than the amount of protein.

Vitamines.—We do not know just what vitamines are, but we do know that growth in the child and health in the adult are very dependent on them. So far three different ones have been discovered: Fat Soluble A, Water Soluble B, Water Soluble C. Fat Soluble A was the second vitamine discovered. It is found principally in butter, egg yolk, and cod-liver oil; also in less amounts in other fats, fish, meat, and vegetables like spinach, sweet potatoes, tomatoes, carrots (young), lettuce, and yellow corn.

Doctor Wells, of Chicago, working for the American Red Cross, found that the Rumanian children were going blind. They had been reduced to a diet of cornmeal and soup made of bran and vegetables. The doctor commandeered a shipload of cod-liver oil and with it performed more miraculous cures of blindness than are recorded in the Scriptures. * * * Europe is full of blind people who need only a little of vitamine A to make them see.

Water Soluble B is found especially in the germ of wheat (it is not present in white flour) and yeast. It is found in smaller amounts in milk, egg yolk, whole wheat, rice, yellow corn, potatoes, young carrots, fish roe, and liver. A baby can be made to gain or lose by giving or withholding Water Soluble B vitamines.

Some pigeons that were completely paralyzed by deprivation of this vitamine were dosed with it and in 60 minutes by the clock they began to coo, and a few hours later tried to fly to their perches.

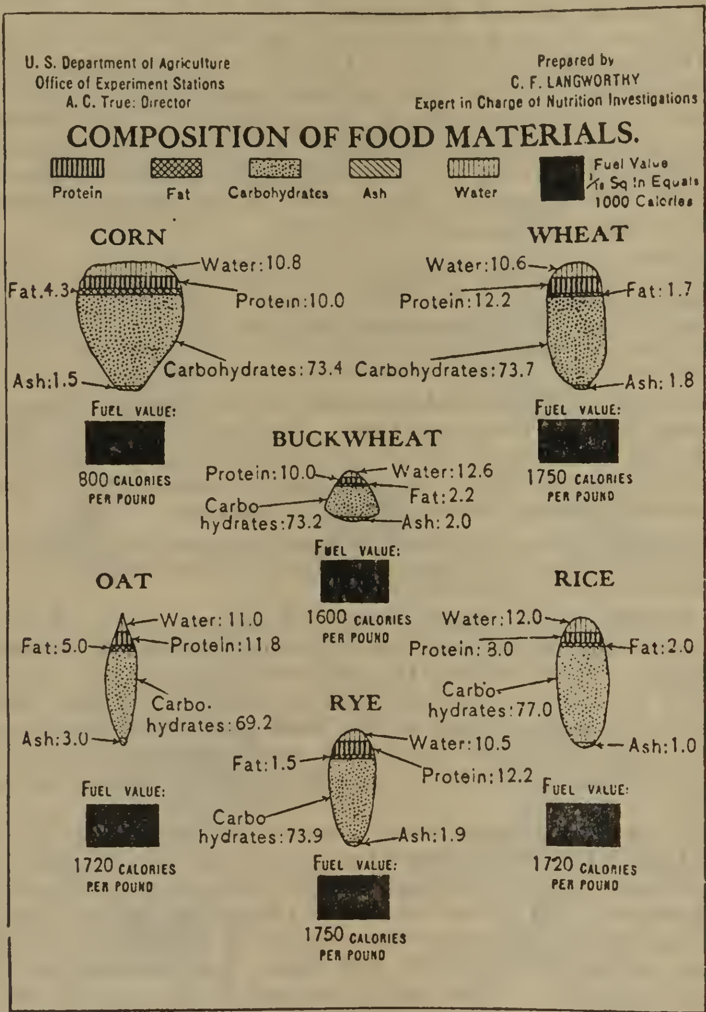
Fat Soluble A and Water Soluble B are not much affected by heat. Age, heat, drying, and canning reduce somewhat the amount of vitamine. Water Soluble C is generally found alone. It occurs mostly in fruits and vegetables, lemons, oranges, tomatoes, onions, young carrots, lettuce, green apples, fresh peas, fresh cabbage, spinach, and potatoes. This vitamine is more sensitive to heat. For example, cabbage is said to lose two-thirds of its value in an hour's cooking.

Water.—Although water is not a food in the true sense, it is most essential to life; approximately 80 per cent of the body is water. It is especially necessary in (1) digestion, (2) elimination (getting rid of waste material), (3) in the circulation (blood and lymph), and (4) in heat regulation. It is the waste formed by the combustion of the hydrogen of the carbohydrates and fats. It is found in all food, but more is needed. Water should be used freely at meals and between. Contrary to popular idea, water drunk at mealtime aids in digestion. It should not be used, however, to wash down partly chewed food. Two glasses at each meal and two glasses between meals is required. Tea, coffee, and milk are included in this amount.

Mineral salts and acids.—The body is composed of organic and inorganic matter. The latter are referred to as minerals and salts. It is the ash in the tables showing the composition of food materials. Iron is one of the most important; it is used in the oxygen-carrying substance of the red blood cells. Foods rich in iron are eggs and

red meats. Of the salts, common salt, NaCl, is most important. Animals like deer are known to travel long distances to a salt lick (a place where the soil is salty).

Before the discovery of vitamines the choice of a proper diet was a matter of securing the proper amounts of protein, fat, and carbohydrate. Such a diet was called a well-balanced ration. From our



knowledge of vitamines we see that it is necessary to choose food that contains these essential substances as well as to secure the proper amount of energy and wear-and-tear materials that are needed in the body. When one adds to these factors the item of cost the problem becomes still more difficult. Where one's income is limited it is necessary to buy with economy, that unnecessary waste be cut so that money is not spent for food which could be saved

to advantage and used to buy clothes and other necessities. It is necessary that the tuberculous person guard his financial outgo as well as his physical.

Bargains in foods.—Foods vary greatly in cost. Proteins and fats are more expensive than carbohydrates; some proteins are much more expensive than others. This applies also to fats and to carbohydrates. For example, porterhouse steak contains no more food value than round steak. On the other hand, butter may cost considerably more than lard, but butter contains Fat Soluble A, and for growing children this vitamine is indispensable. It should be used no matter what it costs. Unless one's income is large, one should buy foods on the basis of utility rather than style. For example, it may be desirable to have a sealskin coat, but one of dogskin may really keep one just as warm. Most people like to buy bargains. Some foods compared with others can always be bought at bargain prices. It is more economical, for instance, to use oatmeal, cream of wheat, etc., for breakfast, than it is to use prepared breakfast foods. The cooked cereals contain more energy and wear-and-tear value for the same cost, providing one has a fireless cooker and does not spend the saving in fuel.

A balanced diet.—There has been a lot of time and effort spent to determine the proper amounts of protein, carbohydrate, and fat needed in the diet. There are some authorities that believe in a large amount of protein, others in a small amount. Amar, the leading French physiologist, says that of the total intake of food one-tenth should be protein. Most American authorities suggest more, up to about one-seventh: or, in other words, that we need one part protein, one part fat, and five parts carbohydrate. For example, it may be expressed in calories as follows: Suppose an individual needs 2,700 calories of food for his daily consumption of energy; 300 of these should be protein, 300 fat, and 2,100 carbohydrate. Nearly every food contains these different substances in greater or less amounts. Meats are spoken of as proteins because they contain a large proportion of protein, but they contain fat and carbohydrate as well as protein. For example, milk is usually thought of as a protein food, but it contains a larger proportion of fat and carbohydrate. One can readily learn the proportions of protein, fat, and carbohydrate in the commoner foods. For practical purposes, however, it is not necessary to figure out accurately the proportions of protein, carbohydrate, and fat. As more energy is required one should increase the amount of carbohydrate and in cold weather the amount of fat. If one will choose at every meal a small portion of one food rich in protein and two rich in carbohydrate—that is, one in starch and one in sugar—besides eating the usual amounts of bread and butter, and some green vegetables for bulk and the vitamines they contain, he will secure enough protein, carbohydrate, and fat for his daily needs and in about the right proportion. The amount of food necessary for a person depends upon his activity and the amount of heat given off. Cold weather and hard work greatly increase the amount of carbohydrate needed. A person should eat according to his needs; that is, his energy requirements.

While the choosing of the right kinds of foods and the proper amounts of each may be made a vocation—for example, dietetics—

for practical purposes, however, the arranging of a diet may be made quite simple. Foods can be listed into five groups as follows:

First. Foods containing body regulating substances, as vitamines, mineral salts, etc.; second, foods containing body building and repairing substances, as proteins; third, foods containing starches, useful for energy, one of the carbohydrates; fourth, foods containing sugar, useful for energy and the other kind of carbohydrates; fifth, foods containing fat; and some food chosen from each group for each meal.

The following lists, with additions, have been taken from a recent bulletin of the Department of Agriculture:

Group 1.

(Foods depended on for mineral matters, vegetable acids, and body regulating substances.)

Fruits:	Vegetables:
Apples, pears, etc.	Lettuce, celery, onions, etc.
Bananas.	Potherbs or "greens."
Berries.	Potatoes and root vegetables.
Melons.	Green peas, beans, etc.
Oranges, lemons, etc.	Tomatoes, squash, etc.
Grapes, etc.	Cabbage, carrots, etc.

Group 2.

(Foods depended on for protein.)

Milk, skim milk, cheese, etc.	Fish, oysters, crabs, etc.
Eggs.	Dried peas, beans, cowpeas.
Meat—beef, mutton, pork.	Nuts.
Poultry.	

Group 3.

(Foods depended on for starch.)

Cereal grains, meals, flours, etc.	Macaroni and other pastes.
Cereal breakfast foods.	Cakes, cookies, starchy puddings, etc.
Bread.	Potatoes and other starchy vegetables.
Crackers.	Rice, tapioca.

Group 4.

(Foods depended on for sugar.)

Sugar.	Candies.
Molasses.	Fruits preserved in sugar.
Sirups.	Jellies and dried fruits.
Honey.	Sweet cakes and desserts.

Group 5.

(Foods depended on for fat.)

Butter and cream.	Salt pork and bacon.
Lard, suet, and other cooking fats.	Table and salad oils.

The following are some sample meals for a family (man, woman, and three small children), taken from a recent Government bulletin:

Breakfast.

Fruit, 1¼ pounds of fresh fruit (equivalent to 3 medium-sized oranges, 5 small apples, or a quart box of strawberries), or 3 or 4 ounces of dried fruits (equivalent to 10 or 12 dates or 4 or 5 figs).
Cereal breakfast food, 4 ounces before being cooked, or about 1½ pints after it is cooked. The equivalent in food value in puffed or flaked, ready-to-eat cereals would be 5 or 6 cups.
Milk on cereal, ¼ cup for each person.
Sugar on fruit, on cereal, or in coffee, 2½ level tablespoons or 1¼ ounces.
Bread, 8 slices, or 8 ounces.
Butter, 1¼ ounces, or 2½ cubic inches.
An egg or 2 ounces of meat, fish or poultry for each older person, and a glass of milk for each young child.

Dinner.

Meat, or fish, ¼ pound per grown person; or, for each child, an egg or a glass of milk.
Potatoes (5 medium sized), 1¼ pounds.
Another vegetable (turnips, spinach, corn, cauliflower, or other), 1 pound.
Bread, 8 slices, or 8 ounces.
Butter, 1¼ ounces, or 2½ cubic inches.
Steamed apple (or other fruit) pudding. (Ingredients: Two cups flour, 2 tablespoons butter, ¾ cup milk, 4 apples, 1 tablespoon sugar).
Sauce. (Ingredients: One-half cup sugar, 1½ tablespoons flour, 2 teaspoons butter, ¼ cup water, flavoring.)

Supper.

A gravy made out of 1 pint of skim milk, ¼ cup flour, 2 level teaspoons butter, and 4 ounces salt or smoked fish (just enough for flavor). To this can be added the egg yolk left from the frosting of the cake. (See below.)
Rice, 8 ounces, or 1 cup, measured before being cooked.
Bread, 8 slices, or 8 ounces.
Butter, 1¼ ounces, or 2½ cubic inches.
One-half of a cake. (Ingredients for whole cake: One-fourth cup butter, ½ cup sugar, 1 egg, ½ cup milk, 1½ cups flour, 2½ teaspoons baking powder.)
Frosting made with 1 egg white and ¼ cup sugar.

Quoting further from this same bulletin:

This grouping will also help the housekeeper who wishes to save money or time to simplify her meals without making them one-sided or incomplete. For example, if she has been serving bread, potatoes, and rice or hominy in one meal, she will see that one or even two of them may be left out without omitting any important nutriment, providing a reasonable quantity of the one or two remaining is eaten. It will show her that a custard which is made of milk and eggs, two foods from Group 2, would hardly be needed after a meal in which a liberal supply of meat had been served, provided one ate heartily of all, and that a child does not need milk at the same meal with an egg or meat. It will suggest that baked beans or other legumes, or thick soups made of legumes, are substitutes for meat rather than foods to be eaten with meat.

This method of planning prevents substituting one food for another which has an entirely different use. It prevents the housekeeper, for example, from trying to give a pleasant variety by using an extra amount of cakes or sweet desserts in the place of fruit and vegetables when the latter seem difficult to obtain. Sugar is nutritious and has a valuable place in the diet, but the nourishment it furnishes is fuel and not the body-building and body-regulating materials which are found in fruits and vegetables, and it is not safe to cut them out, even if the meals can be made attractive without them. Fortunately, they are not always so hard to obtain as it seems, and the wise housekeeper will make every effort to supply them. In general, economy within each group is safer than using an inexpensive food from one group in place of an expensive one from another group.

Thinking in terms of these groups will also help when laying in supplies. Dried peas and beans and dried fish, canned fish, and meat, and some kinds of

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cheese keep for a long time and can be used in place of fresh meat in an emergency. Fruits and vegetables put up when they are abundant will help to supply this important group in winter.

Project No. 10.—Meal Planning on a Cost Basis.

Problem: How to plan meals on a cost basis.

Data: Prices of food and table of foods listed in the five groups.

Direction: Using the sample meals as an example, plan the meals for a day for a family of five (two adults and three small children). Then figure the cost. Plan three meals to cost about 50 cents more a day.

Demonstration No. 9.—Tests for Foodstuffs.

Problem: How to test for (*a*) starch, (*b*) protein, (*c*) fat.

Apparatus and materials: Test tubes, an alcohol lamp, samples of starch, protein, fats. Tincture of iodine, nitric acid, ammonia water.

(A) Directions: Mix a teaspoonful of cornstarch in about two teaspoonfuls of water in a test tube. Add a drop of tincture of iodine. (Is there any change in color?) Heat carefully over a flame for two or three minutes and allow to cool. Add another drop of tincture of iodine. Note the color. Heat again.

Questions: Why was there no change the first time the tincture was added? What effect does heat have on the starch cells? Is the change chemical or physical?

(B) Directions: Put a small piece of meat in a test tube. Add a little diluted nitric acid. Heat carefully for two or three minutes. Cool and wash the piece of meat in water, then add a few drops of ammonia water. Note the color.

Questions: Is the change chemical or physical?

(C) Directions: Place a small amount of any kind of fat, as butter or lard, on a piece of paper. Heat it gently. Wipe the fat away and note what happens to the paper.

Questions: How would you describe it? Is the change chemical or physical?

Project No. 11.—Composition of Foods.

Problem: How to prepare a list of common foods showing composition.

Directions: Test several foods for proteins, starch, and fats and list in a table; + for present; — for absent, as follows:

Name.	Protein.	Starch.	Fat.
Rice............	–	+	–
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

Project No. 12.—Cost of Protein and Fat.

Problem: How to figure food values on the per cent of protein or fat.

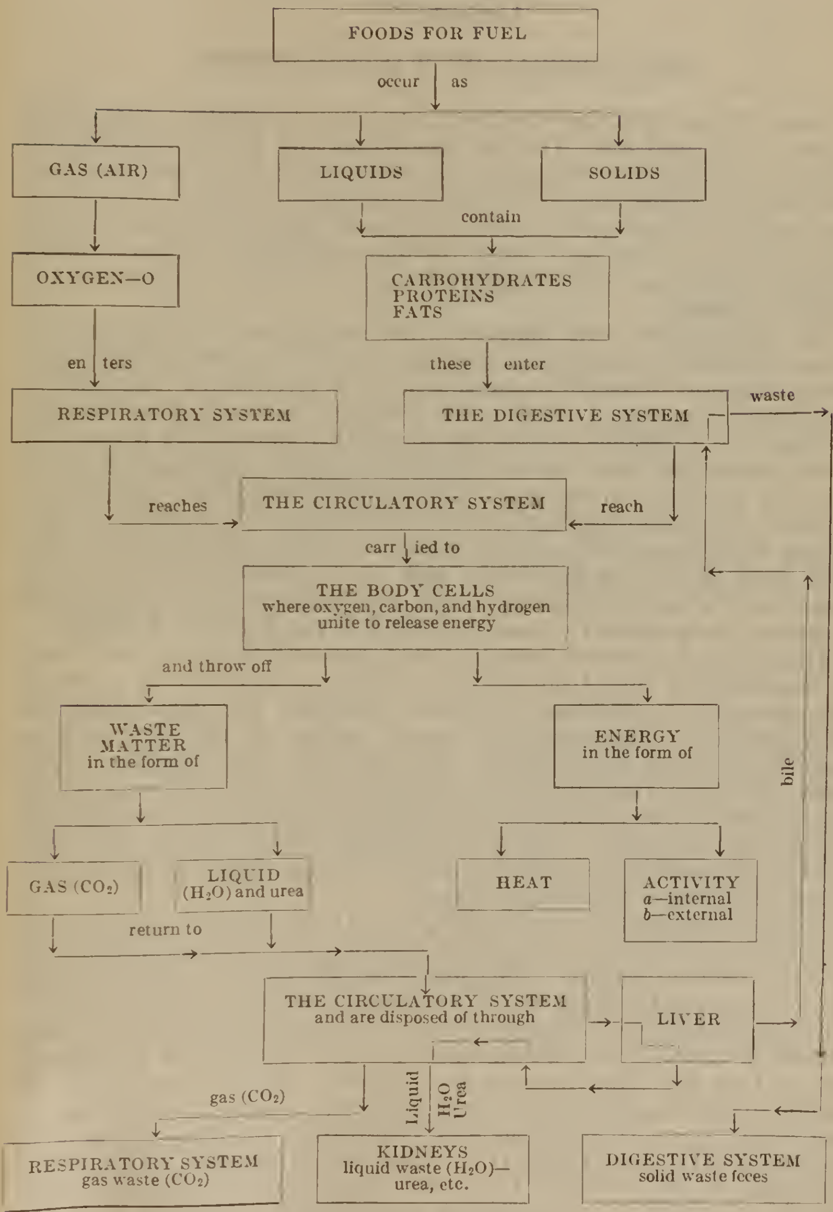
A. Choose 5 foods rich in protein; find the per cent of protein and fat from the food charts. The daily papers will give the cost per pound. From these data figure the cost of (1) a pound of protein; (2) a pound of fat. Consider the balance as waste.

B. Choose 5 foods rich in carbohydrate. Figure the cost of a pound of carbohydrate, considering the balance as waste. Do the same with the fat and protein, if either is present.

Project No. 13.—Food Values on Calory Basis.

Figure the cost of 1,000 calories of each of these 10 foods and list in a table—the most expensive first and the cheapest last.

VITAL COMBUSTION CHART.



Prepared by R. Milton Hall.

Chapter V.

THE DISPOSAL OF WASTE MATTERS.

Every living cell, every living animal, has to get rid of its waste matters or it will die. Do you recall how the home brew stopped working because alcohol, one of its waste matters, accumulated and poisoned the yeast cells? The yeast cells died because they were not able to live in their own waste and because they had no way of getting rid of it. The body cells are more fortunate. They are not killed by their own waste matters because they have means for disposing of them.

The disposal of waste matters is not usually well understood because it is accomplished by several systems. When one studies elimination disposal of waste he must study the circulatory, respiratory, and digestive system as well as the liver, kidneys and skin, for each of these has a distinct part in the disposal of waste. It is easy for one to forget that these systems and organs have a disposal as well as a supply function; for example, when one thinks of the respiratory systems it is more usual for one to recall simply its function of supplying oxygen and to forget its disposal of the gaseous waste, CO_2. This state of mind is due to the lack of emphasis given to the importance of waste disposal and to the fact that the disposal of wastes is carried on by several systems as a part of the duties or function.

The disposal of waste from the body cells and the body itself may be compared to that from private houses and the city as a whole. You recall how important the water, sewerage, and garbage system of a city are. The water and sewer system of the city may be thought of as the blood stream, for just as the blood stream carries away the waste from lymph surrounding the cells, so the sewerage system carries away liquid and semiliquid waste from the individual houses and buildings. While the garbage wagon carries away the solid waste just as the digestive system disposes of the undigested and other solid wastes through the feces.

Another comparison may be helpful. If one has ever had experience with a furnace or a hard-coal stove he knows what clinkers are and the trouble they give. The smoke readily passes up the chimney. The ashes pass through the grate into the ash box or ash tin, but with the clinkers it is different. They do not pass through but remain behind in the fire box. Sometimes it is necessary to let the fire go out so that the clinkers may be removed. In the combustion of carbohydrates and fats the wastes are easily disposed of because, as you recall, the carbohydrates and fats consist of only carbon (C), hydrogen (H), and oxygen (O). The carbon burns to CO_2 and the hydrogen to H_2O. The CO_2, as we have learned, is taken up by the blood stream from the lymph and is finally disposed of in the lungs. The water of course does not need any disposal, but in the combustion of proteins, which are composed of carbon, hydrogen,

oxygen, and nitrogen and sometimes phosphorus and sulphur, there are other wastes besides CO_2 and water. Part of the carbon burns to CO_2, part of the hydrogen to H_2O and the balance of the carbon and hydrogen with the nitrogen and the other elements burns to wastes that are gotten rid of with considerable difficulty. They may be compared to the clinkers in the fire box which stick in the grate. Protein wastes are not readily disposed of. They do not filter out through the kidneys and skin except after special preparation or treatment. One of the very special functions of the liver is to prepare the protein clinkers for later disposal through the kidneys.

It should not be concluded, however, from what has been said above that the protein foods should always be limited to the very minimum. Protein foods are building, replacing, and repairing foods. A certain amount is necessary every day, and a good deal of controvery has arisen in trying to decide the proper amount to be eaten. Besides, protein foods, as meats, have a stimulating effect. Meat-eating nations are more progressive than vegetarians. It is the abuse and not the use of protein foods that is unhygienic. A moderate amount of protein is needed every day. Carbohydrates and fats may be stored up, but there is no way to save an excess amount of protein. If more is eaten than is necessary it is burned. This excess throws an additional amount of waste into the blood—extra work for the liver and kidneys.

In the study of elimination it will help one to divide it into two parts, internal and external disposal. The internal disposal is concerned with the preparation and transportation of wastes to their points of exit from the body. External elimination is the disposal of wastes through the four great exits.

Internal Disposal.

Internal disposal of wastes is accomplished principally by the blood and the liver. It is a matter of transportation and chemical action (a partial combustion). The blood removes the waste from the lymph surrounding the cells; it carries the CO_2 to the lungs for disposal; it carries the waste from protein combustion to the liver. In the liver some of the wastes are prepared for elimination by the kidneys. The other part of the waste is emptied directly by the liver cells in the bile capillaries. This function of the liver to prepare protein wastes for ultimate disposal in the kidney has been given but little consideration because it is only of late years that this function of the liver has been understood.

The liver.—The liver is one of the most important organs of the body. Its functions are numerous and may be summarized as follows:

1. At birth it contains an excess of iron, for milk, the natural food of the infant, does not contain iron. The liver provides a supply until the child begins to eat other foods, as eggs, which contain iron.
2. It has an internal secretion which assists in the storage and combustion of the carbohydrates.
3. It is the chief organ for the destruction of worn-out red blood cells.
4. It has an important part in the regulation of the coagulation of the blood. It supplies anticoagulation bodies.

5. It plays an especial part in heat control or regulation.
6. It excretes the bile.
7. All the digestive food absorbed into the blood passes through the liver before it is allowed to enter the general blood stream for circulation through the body. It filters out and destroys the poisons from the blood.

The liver weighs about 3 pounds. It lies on the right side of the body, just below the diaphragm and to the right of the stomach. All the venous blood from the digestive system passes through the liver on its way back to the heart. The blood laden with digested and absorbed foods comes to the liver by way of the portal vein. This vein divides into smaller and smaller vessels until it ends in capillaries like the arteries. The portal vein capillaries do not have a distinct wall like the arterial capillaries of the body. In places the liver cells form the wall. This arrangement gives an unusually good opportunity for the liver cells to gather in the poisonous matters as they pass by in the blood. In fact, the liver may be thought of as a great filter that filters out of the blood poisons that have been absorbed from the digestive system, as well as the poisonous wastes from protein combustion.

The liver cells lie between the capillaries of the portal vein on one side and small bile vessels called biliary capillaries on the other. The liver cells therefore are arranged to discharge their insoluble wastes and other substances for the making of bile into the biliary capillaries and their soluble wastes back into the blood stream for final disposal by the kidneys.

The liver may be thought of as standing on guard—as the first line of defense. It does its utmost to protect the body from poisons absorbed from digestive system and from those arising from slow combustion in the body cells. The liver bears the brunt of the attack. For example, the surface of the liver of a chronic drinker of whisky and other alcoholic liquids becomes so pock-marked that it is spoken of as a hobnailed or gin drinker's liver. In its function of the removal and the destruction of alcohol that has been absorbed in the stomach and intestines, the liver has become so injured that its surface has the irregular appearance of the bottom of a hobnailed shoe. In fact, one may think of such a liver as a shell-torn, partly destroyed village, and the alcoholic drinks as the shells which have injured and destroyed the liver cells.

To sum up, one may say that the liver is a very important organ in elimination. It prevents the poisons absorbed in digestion from entering the general circulation. It prepares the protein clinkers for disposal. The insoluble part of the clinkers it discharges directly into the bile and the soluble part it prepares for later elimination from the blood by the kidneys as urea and allied substances.

EXTERNAL DISPOSAL.

There are four great exits or ways by which the waste leaves the body. These exits in order of their importance are (1) the respiratory system (the lungs), (2) the kidneys, (3) the digestive system, and (4) the skin. The respiratory system comes first, for one can live only a few seconds if CO_2 is not disposed of. The kidneys next because one can live only a few hours if the protein wastes are

allowed to accumulate in the blood, but one can live days without elimination of waste from the digestive system and a person has been known to live for years without taking a bath. The wastes disposed of by the lungs, the kidneys, and the skin are true body wastes. The waste from these organs are the waste product of combustion and the end products of repair. On the other hand, part of the wastes from the digestive system never were an actual part of the body even though they were within the digestive tract for several hours or longer.

We have considered the elimination of CO_2 in our study of the respiratory and circulatory systems. It may be reviewed by referring to the chapter on the respiratory and circulatory systems. There remains to be studied elimination in the kidneys, digestive system, and skin.

The kidney.—The kidney is the most important organ for the external elimination of waste, but like other great organs it has more than one function. In fact, the kidney should be thought of as the great regulator of the composition of the blood. By its ability to excrete water and the various other substances found in the urine it has an accurate control over the exact composition of the blood. During health the percentages of the various forms of matter composing the blood are very accurately regulated, so that they vary but little. The kidney is the chief exit for the disposal of the end products from protein combustion, the so-called protein clinkers; but this function of waste disposal is really secondary, or a part of its regulation of the composition of the blood and its function of regulating the amount of water in the body; that is, in the blood and lymph. One should not think of the kidneys as great filters where the wastes from the body are eliminated, but rather as regulators as having the ability to control the composition of the blood by picking out substances that are poisonous or injurious as well as by controlling the percentage of the normal substances in the blood. For example, the kidney does not allow the blood to become too watery, and in a disease like diabetes, where the sugar control is injured and the percentage of sugar in the blood tends to increase, sugar very promptly appears in the urine because the kidney cells do not allow the percentage of sugar in the blood to increase. In other words, the kidney cells regulate very accurately the amount of water and sugar in the blood and will not allow these to increase beyond a certain amount. The functions of the kidney are so important that if both kidneys are removed from an animal it very soon dies. When one only is removed the other kidney enlarges and takes on the function of both. Kidney cells are in continuous operation.

Urine.—The excretion of the kidney is called urine and passes every 10 to 20 seconds by a tube from the kidney to the bladder. In the bladder the urine accumulates until there are from 230 to 250 cubic centimeters. On the average this filling takes from 3 to 4 hours during the day. On the average about 1,500 cubic centimeters of urine are excreted during 24 hours. Urine is composed in part of inorganic salts, as common salts and organic salts and substances of which urea and uric acid are the principal ones.

Disposal of waste from the alimentary canal.—Passage of food through the body takes from 25 to 30 hours. The food passes through the alimentary canal at different rates of speed; it passes

from the mouth through the gullet into the stomach in 3 or 4 seconds. The normal stomach empties itself within about 4 hours. Water passes through it very quickly, within a few minutes. Carbohydrates, as sugar, pass through next quickly, followed much slower by the proteins and most slowly by the fats. The stomach and small intestine together measure about 21 feet. Food travels through the stomach and small intestines in from 7 to 9 hours. Although the large intestines measure a little less than 5 feet, it takes food from 18 to 21 hours to pass. It is evident, therefore, that a disposal of waste should occur at least once every 25 to 30 hours and usually once every 24 hours, for on rising in the morning the food waste in the transverse colon passes into the descending (going down) colon and aided by gravity falls more quickly into the rectum for disposal from the body. The waste from the alimentary canal is composed largely of undigested food bile and other body waste, bacteria and their poisonous waste. There is usually very little absorption except water from the large intestines, but any stoppage of the natural flow of waste gives rise to disorders from the absorption of poisons from the increased growth of bacteria. The writer has seen patients acutely ill with fever as high as 103 who recovered very promptly following a large dose of castor oil. Such patients are said to be suffering from autointoxication; they are really being poisoned from poisonous matters developed in the large intestines due to the stoppage or delay of the disposal of waste.

The alimentary canal, especially the large intestines, has been called the great sewer of the human system. Its regular cleansing of body waste is most important. Improper disposal of waste from the alimentary canal or cleansing of the human sewer is due largely to bad habits in eating, drinking, and taking of exercise. The savage or wild man is not troubled with chronic constipation. He does not know the taste of castor oil or salts; he lives a simple life. It is only when man changed his habits and became civilized that he began to suffer from this disorder.

The cure for constipation is usually a difficult one, for the condition is chronic and it is easier to take medicine than it is to form correct health habits. The cure consists in the discovery of the cause or causes and in the removal of them. If the causes can not be readily discovered, great help may be secured by giving attention to proper habits of eating, exercise, etc. Food that contains more indigestible substances as found in the bulky vegetables are useful, and the eating of natural laxative foods as prunes and figs as well as fruits is of advantage. It is advisable to have a regular time for going to stool. The best time is directly after breakfast. Some find that the drinking of a glass or two of warm water on rising helps to stimulate the flow or passage of the waste into the rectum. Regular habits and the little things are what counts. Avoid medicine except in emergencies.

The skin.—Usually the skin plays a very small part in the elimination of waste, but under certain circumstances it can be made to assist to quite a degree. The skin contains two different kinds of glands. One kind pours out oil and the other sweat. The oily glands pour out an oil that keeps the skin soft and pliable. There are two billion sweat glands. They have an important place in the regulation of body temperature and a very minor place in the elimi-

nation of waste. The sweat is composed principally of water. There are, however, very small amounts of urea, allied bodies, and CO_2. Except during hot weather, when the amount of sweat is greatly increased, the amount of waste thrown out by the skin is very small. In diseases of the kidney, where the disposal of waste is reduced, hot baths and sweating can increase the amount of waste many times and be made a real factor in the disposal of protein wastes. Proper hygiene of the skin requires that one should take at least one, preferably two, cleansing baths a week. If one perspires a great deal he may need one every day. These baths of course are in addition to the cold shower which should be taken every morning, provided the individual gets the proper reaction (feels warm) following the bath. The warm baths are needed to remove the waste from the skin. These wastes if not removed close up the openings of the glands commonly known as pores. This blocking of the pores interferes with heat regulation—the principal function of the sweat glands. Waste elimination from the skin is very small.

PART II.

THE HUMAN MOTOR.

Chapter VI.

STRUCTURE.

We began our study of the human body with the cell and its relation to matter and energy. We followed by studying the great system of the body (digestion, respiration, and circulation) which furnish food and oxygen, dispose of CO_2, and carry away the other waste that result from slow combustion in the cells. We are now prepared to study how the body uses the energy released for useful labor and for recreation; that is, how the human body acts as a motor. For its purposes the human motor is very suitably arranged. It is compact, with no useless parts. It is a wonderful machine, a thing of beauty, and in health a joy until death. When trained, harmony, order, and efficiency are evident in all its actions. Before beginning this study of how the human motor works we will review briefly our knowledge of its general plant and structure.

The bones of the body form a framework called the skeleton. The skeleton gives shape and form to the body; it protects delicate and vital parts, and it furnishes the rigid parts through which the muscles are able to deliver their power and force. The skeleton is not a rigid framework; it is movable on itself at certain points. These points, where the bones are joined and more or less movable together, are called joints. The amount of motion in a joint may be great or small as there is necessity for motion in that location. For example, the joint between the collar bone and breastbone is almost immovable, while at the shoulder joint the amount of action is very great. The bones of the head surround the brain and the spinal column surrounds the spinal cord. The lungs and heart are protected by the ribs. The structure of bone is well adapted for its purpose. Near the end of the bones, where they are joined together, the bones are larger and the formation is less dense. Mechanically this allows greater areas for tying the bones together. The shaft of the bone is hollow, as that shape has the greatest strength for the amount of bone substance. Bones are about twice as strong or resistant as pine wood, but mode of life and training modifies them. It is said that the race horse fed on oats and hay has denser and stronger bones than the grass-fed horse. The bones of strong men are more irregular and rough on their ends. This roughness affords better attachments (places to tie) for the ligaments and tendons of muscles. By these signs an expert is able to tell from the bones of a skeleton whether its owner was strong or weak.

TENDONS AND LIGAMENTS.

The bones are joined and held together at their ends by connective tissue called ligaments. Ligaments and tendons are of the same tissue; that is, composed of the same kind of cells. This tissue is tough and elastic; it contains few or no blood vessels, and for this reason heals very slowly when injured. Muscles are not directly connected to bone, but end in tendons which are joined to the bones. Injury to the ligaments about a joint result in a sprain or dislocation. Where there is a complete separation of the bones, we speak of it as a dislocation. Where there is only a partial separation, as a sprain. In either case there has been some tearing away of the ligaments from the bones. Sprains and dislocations are serious injuries. They take a long time to heal and should always be treated under the direction of a physician to avoid chronic conditions that follow neglect.

Tuberculosis of the bones is common in childhood. The disease begins near a joint which sooner or later becomes involved. The hip joint and spinal column are common locations for tuberculosis of the bones. The hunchback is the result of tuberculosis of the spinal column which has not been properly treated. As a result the spinal column becomes bent and twisted. The right kind of medical treatment can prevent these great injuries to the spine.

MUSCLE TISSUE.

We are all familiar with muscle tissue. It is the red meat of animals. It is one of our most important foods (protein). It composes about one-half of the weight of the body. It is the active part of the human motor, that part which transforms energy into motion—active power. Muscle tissue is well supplied with blood. It is said that during active exercise four or five times as much blood passes through the muscles as during rest, for the muscle tissue depends upon the circulation of the blood for its supply of energy and for the disposal of its poisonous waste products that result from the slow combustion in the muscle cells. During activity greater supplies are needed and more waste matter is formed.

THE MUSCLE CELL.

The function of the muscle cell is to overcome resistance. It does this by developing power and force. The muscle cell develops power by its ability to change its shape—to contract and relax. When the muscle cell becomes thicker and shorter it is said to contract. When it becomes longer and thinner again, it is said to relax. Both of these actions are necessary in its function of transforming energy into coordinated movements. Normally the muscle cell is slightly contracted. This condition is spoken of as tone. It enables the muscle cell to get into action rapidly. As we will learn in our study of the nerve cells, muscle cells do not react, they do not work except upon orders from the motor nerves. Motor nerves end in the muscle cells in what are called end plates. These end plates deliver the orders that bring the muscle cells into action. The end plates deliver these orders by impulses. Muscle cells, like neurons, are

impressionable—that is, sensitive—and especially are they sensitive to the end plates of the motor nerves. But the muscle cell does not react immediately upon impulses from the end plates. There is a short delay before the cell begins to contract. In certain conditions, as in fatigue, illness, etc., this period of delay increases, for the sensitiveness of the muscle cell changes. As it becomes less sensitive more impulses are necessary to bring it into action. As we shall see, this delay in reacting to nerve impulses because of the decrease in sensibility to motor nerve impulses is a decided factor in the development of fatigue.

NEUROMUSCULAR SYSTEM.

The relationship between the nervous and the muscular system is very close. The muscles do not act without orders from the nervous system. One may think of training for skilled physical labor, as being really as much nerve as muscle training. It will help us to understand the nature of movements and muscular activity if we think of them as resulting from the neuromuscular system. In the study of the nervous system, we learn that the hind-brain controls automatic action. The hind-brain is able to do this by information that it receives from the sensory nerves endings in the muscles. The sensory nerve endings keep the hind-brain accurately informed as to the state of contraction and relaxation of several muscles employed in any movement. All our motions and movements are the result of the contractions and relaxations of muscle cells, but in any movement all the muscle cells are not contracting or relaxing at the same time. Movements are complicated acts; at the least two muscles and sometimes several, are in action to bring about any movement. Muscles are balanced one against another. They usually work in pairs against each other, but the opposition is friendly; while one muscle is contracting its opponent is relaxing. This balance permits very delicate movements. It enables the workman to carry on efficiently. Note the skilled mechanic at work. There is a smoothness, a regularity, in all his action. There is a rhythm, a harmony, in his movements like that of the professional dancer. It is the result of a trained neuromuscular system.

But this harmony, this ability to work with skill, is acquired; it is learned through practice. Note the baby learning to walk. He has difficulty, not because his muscles are not strong enough to support his body, but because he has not learned how to order correctly the contractions and relaxations of the muscles of his legs.

The voluntary muscles of the body are the active part of the human motor. The amount of work they can do may be rated in horsepower. For a short time as high as one-half horsepower has been developed, but the average working man can not produce continually for eight hours more than about one-seventh of a horsepower.

THE NERVE CELL, OR NEURON.

The basis of all nerve action is the cell, the neuron. A neuron may be long or short. Some are less than an inch; others reach 2 or 3 feet in length. The ends of a neuron look like the roots of a tree—a mass of fine branches which are closely connected, but not actually

joined to another neuron. Neurons are always connected, end to end. They are insulated from each other except at the ends. The active part of the neuron is grey in color. That is why a bright person is often spoken of as having lots of grey matter. A neuron has three qualities: (1) Impressibility; (2) conductivity; (3) modifiability. These terms may be new and somewhat hard to remember, but they are really more simple than they appear to be. Impressibility means that the neuron is sensitive; that it is easily affected by anything. For example, but few of us have escaped an aching or sensitive tooth. Decay exposes the nerve in the tooth, and as the nerve is not protected it is easily affected. Conductivity means that when the neuron is affected or receives an impression, it carries the impression along to the next neuron. Modifiability means that any experience, sensation, or any action of the neuron leaves its mark or stain. The neuron has become changed or modified. In short, the neuron is easily affected; it carries or conducts this feeling, impression, or influence to the next neuron and it remains changed or modified; it is never the same again.

We may recall in the many-celled animals there has been a division of labor; so among the nerve cells or neurons, and this division is based on the three qualities that we have just studied. (1) Some neurons specialize on receiving impressions or sensations; (2) some neurons' chief work is carrying on or conducting nerve currents; (3) other neurons' chief duty is to become changed or modified, and in this manner store away impressions or sensations for future use.

The entire surface of the body is richly supplied with nerves. It is the duty of these nerves to keep us in touch or informed of things about us. These nerves are specialized groups of neurons called nerve endings. These nerve endings have special jobs to do. Under the skin there are special nerve endings for touch, heat, and cold. The nerve endings that feel heat do not feel cold. There are separate nerve endings for (*a*) heat, (*b*) cold, and (*c*) for touch. The nerve endings in the eye are affected by light and color. One sees stars when hit on the head because the nerves in the eye are affected, but as they conduct only light impressions one sees light, he does not feel the pain. They are insensitive to other sensations. The nerve endings in the ear are affected by sound waves in the ear. The nerve endings in the tongue are affected by things bitter, sweet, sour, and acid—separate endings for each. The nerve endings in the nose are affected by things having an odor. All of these nerve endings are affected by one kind of sensation and are insensitive to others. There are also nerves in the various organs of the body, muscles, joints, etc., which note any changes that go on in these areas and by means of conducting neurons they keep the higher part of the nervous system informed of just what is going on in the body. We may think of these nerve endings as news gathering stations. After the news is collected it must be carried to the brain and spinal cord. This conduction or transportation of nerve news is the special job of other neurons. Where many neurons are joined together to carry or conduct nerve news, they are referred to as a "track." Nerve action or conduction may be better understood if one will think of that which affects a neuron as a stimulus, and that this stimulus causes impulses. These impulses may be thought of as waves or currents passing along

the neurons. At the end of the neuron the impulses act as a stimulus causing impulses in the adjoining neuron. In this way nerve news or nerve currents are passed from any part of the body to the brain and spinal cord. The neurons that carry impulses to the brain and spinal cord are called sensory nerves, because these impulses result in sensations. Nerves composed of neurons that carry impulses from the brain and spinal cord to the muscles are called motor nerves, because their messages bring about motion or activity.

PERSONAL EQUATION.

Impulses are conducted in neurons faster in some individuals than in others; that is, persons vary in the speed of their nerve reactions. Some have slow, others have a quicker, reaction. We speak of this difference in reactions as the personal equation.

It has been found by experiment that it takes on an average fourteen one-hundredths of a second for one to press a button, after he has been touched; that it takes fifteen one-hundredths of a second for one to press a button after he has heard a sound; and that it takes nineteen one-hundredths of a second for one after seeing red or blue to press the same colored button.

It has been found that one's personal equation varies from hour to hour and from day to day. It is slowed up by fatigue, and distractions, like organs and bands playing, increase very materially the time required for nerve reaction. Training and habit in a sense do shorten the personal equation, for, as we will learn, habits make pathways along certain neurons. The nerve impulses have a tendency to run along these pathways because less effort is required. One may say that the nerve impulses take these pathways the same as one follows the road, because he can travel easier and faster by so doing.

It is important that one should know his capacity so that he may judge his ability to do. for to attempt to do a job that demands a pace or speed that is too rapid for his personal equation is the same as attempting to do a job that requires strength beyond his physical capacity. It is like overloading a weak man with a heavy load.

Conducting neurons are usually grouped together in "tracks." They may be thought of as pathways or roads connecting up all the different parts of the body with the brain, and the brain with all parts of the body. Not only are there pathways of conducting neurons leading to and from the brain, but the several parts of the brain are connected together in a similar manner. The pathways joining together the several parts of the brain are most important; they are called association tracks, because they bring together the different parts of the brain and permit of the many complicated connections and associations of sensations and ideas. Without these connecting pathways the higher functions of the brain could not be carried on. For example, when one sees some apple pie or smells frying bacon, he feels hungry and his mouth begins to water. In the one case the sight of the apple pie, in the other the odor of the bacon, through the connections in the brain brought about the sensation of hunger and started the flow of saliva in the mouth.

We have considered so far two of the three qualities of the neuron—impressibility, that quality of being easily affected by anything, and

conductivity, that quality of carrying nerve news through itself and delivering it to the next neuron to which it is connected. We have still to consider modifiability, that quality of the neuron to be modified and changed by its action. We will take up further this modification or change of the neuron when we come to the study of memory, for memory is based principally on this quality of the neuron.

THE BRAIN.

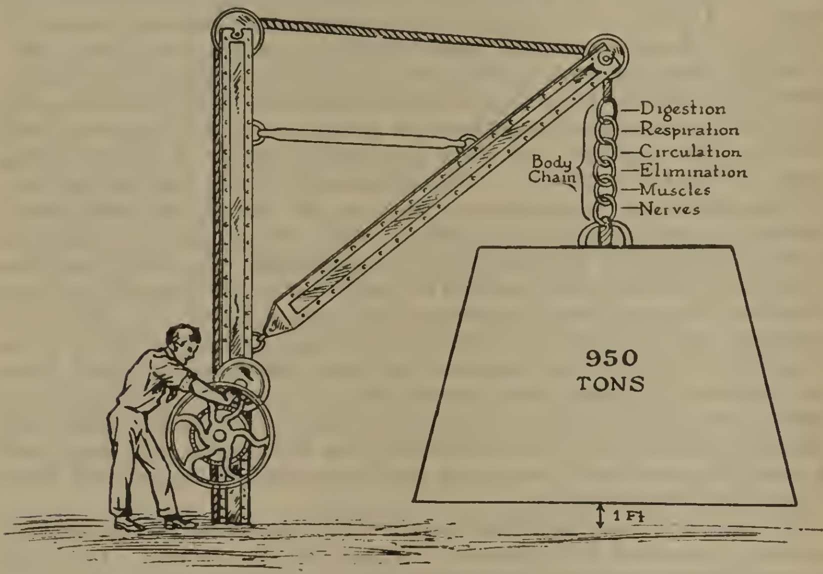
The brain is situated in the skull, surrounded and protected by bone. The skull is located at the upper end of and connected with the spinal column, which protects the spinal cord. The brain proper may be divided into three parts or divisions: (1) The fore-brain, (2) the mid-brain, (3) the hind-brain. The fore-brain is the organ for thought. Injury to the neurons of the fore-brain destroys the power to think, will, and feel. No longer are we able to see, hear, taste, feel, or smell. It is the seat of the five senses. The fore-brain is highly specialized. It has special cells for its different kinds of work, and these cells are grouped together and located in definite areas called centers. For example, we have the speech center, writing center, vision and hearing centers. These centers are joined together by connecting pathways of neurons, which, as we recall, are association tracks. By means of these special centers and by these association tracks one is able to do a variety of complicated acts. For example, when one wishes to speak, orders are sent to the speech center to issue orders to the muscles that have to do with talking; or when one wishes to write, orders are sent to the writing center, and it in turn issues orders to the muscles in the hand and arm that make and form the letters. Or again, the nerve endings in the eye send nerve currents to the vision center. The vision center by its connections with other parts of the brain, enables the person to see form and color and to recall the names of the colors and the names of the objects from which the forms come.

The hind-brain.—The hind-brain is the great center for the coordination of muscular movements. It is the red-tape center. It is able to coordinate muscular movements because it is a great center for receiving nerve currents from muscles, tendons, and joints; these nerve currents furnish it with information. This information is very accurate and enables the hind-brain to accurately balance the action of the opposing muscles. When the fore-brain issues an order for any movement that has been done many times before, as for example to walk, the necessary orders to the muscles may be issued by the hind-brain. It is not necessary for the fore-brain to more than will to do. The hind-brain takes over the job and secures the teamwork that is necessary for the muscles to act in unison. Note how the drunken man staggers. Alcohol has affected the neurons of his hind-brain. The information that it receives is inaccurate and the muscles are not sent the proper orders. The man can not walk except with much difficulty; he must order every different movement. He is like a baby trying to walk. A tumor or cancer located in the hind-brain injures the neurons and the individual affected walks much as if he were intoxicated. The mid-brain and upper part of the spinal cord control the vital functions of the body. The most

important of the vital functions are breathing, digestion, and the circulation of the blood. So far as life is concerned, this part of the brain is most essential. Injury will cause instant death, but it is well protected and injuries are rare.

THE SPINAL CORD.

The spinal cord is connected with and is a direct continuation of the mid-brain. It descends in a canal in the midst of the spinal column for over 2 feet. In its course downward it gives off 31 pairs of nerves, which extend to all parts of the body. All nerve messages from the body travel to the brain by way of the spinal cord.



A man is able to do an amount of work equal to lifting 950 tons one foot high, but every link in the body chain must be strong. When any link of the chain is weak the amount of work is reduced that much.

Chapter VII.

PHYSICAL LABOR.

THE NECESSITY FOR LABOR.

Labor is a necessity. The body must be clothed, fed, and shelter provided. These things are obtained by labor. One may not labor, but he can not live except on the things that are produced by labor. Everyone should labor, for a moderate amount of labor is healthful. In olden times man labored under great difficulties. Before he discovered the use of fire and machinery life was a burden. Now that he is able to harness the active forces of nature (the waterfalls, the winds of the atmosphere and can turn the wheels of industry by releasing energy stored in coal and gasoline), he has greatly shortened his hours of labor. But labor is still in demand, for the desires and wants of mankind are ever increasing. The luxuries of to-day become the necessities of to-morrow.

To labor is healthful. It is unfortunate that the idea ever arose that labor is an evil—punishment for sin. The idea evidently arose in early times, for in the Bible story we are told that Adam and Eve lived in a beautiful garden where they enjoyed a life of ease free from the burden of daily labor. It was not until after the devil in the form of a serpent had tempted them to eat of the forbidden fruit of the Tree of Knowledge that they were driven out of Eden and Adam was told that henceforth he must earn his bread by the sweat of his brow.

It is physiological to labor.—In the Torrid Zone of the southland, where it is easy to secure food and clothing and shelter, the races of man have not been strong and warlike. It is in the Temperate Zone of the northland, where it is a continual battle against the elements, that the strongest races of man have lived. For it is through resistance, through struggle, through effort, and labor that men have developed powerful bodies and keen minds. But this strenuous life is not physiological or healthful for the tuberculous. The reduction of labor in time and hard physical effort, which has been brought about by inventions, machinery, and power, enables the arrested tuberculous case to reduce his physical efforts. By training his mental power he is able to earn a living and become an economic member of society.

TRAINED TO LABOR.

Everyone should know how to labor to advantage, even though he has no special need for economy in his physical output of energy. With the tuberculous, however, it is a necessity. He must know how to produce the most labor with the least amount of effort. He must conserve his physical energy releasing function. He must be trained so that he can compensate by mental effort his physical defect. The

human machine does not operate like an inanimate motor. The element of fatigue enters. Labor brings on fatigue and finally prevents all further labor.

FATIGUE.

Fatigue is usually thought of as a sensation, but it is more than that. It affects one's ability to work. In the beginning it acts as a stimulant; it increases one's ability to labor. This increase, however, soon passes away and from then on fatigue decreases one's capacity for labor. Fatigue is a condition that is developed by cellular action, nervous or muscular. A slight amount of fatigue is normal. It is physiological. Danger lies in the development of chronic fatigue. Where rest and sleep are able to restore the desire and ability to work fatigue is healthful. Fatigue is protective. It is nature's way of guarding the body cells from overdoing. The study of labor and fatigue go hand in hand, for the study of how to labor efficiently is largely a study of how to delay and prevent fatigue. It is worth while to learn the nature of fatigue; how it may be controlled; its general laws and one's own reaction to fatigue. This knowledge will help one to labor more efficiently.

The fatigue poison in the blood.—Fatigue is essentially an intoxication. It is caused by waste products produced in the freeing of energy in the body cells. These waste products are poisonous. They are taken up by the blood and so are able to affect the whole body. The presence of these poisonous wastes in the blood has been proven by experiments on frogs and dogs. An amputated frog's leg fatigued by an electric current so that it will not contract any more, may be made to contract again by circulating water (slightly salty) through the blood vessels of the frog's leg. Mosso found that when he tried a dog by working him all day, and took the blood of the tired dog and injected it into the blood vessels of a rested dog, that the rested dog then developed all the signs of fatigue that the tired dog had shown.

Fatigue wastes depressing poisons.—Fatigue poisons are similar in their action to poisons that depress—that is, sleep-producing drugs; for example, ether and opium. It is characteristic of these poisons that in the beginning their action does not produce depression. For a short time they act as stimulants. When a patient, for instance, is put to sleep with ether before an operation he usually struggles and often cries out. It may take several people to hold him on the table if he is not strapped or tied to it. Opium acts in a similar manner. The pleasant dreams of an opium smoker or eater are experienced during the short period of stimulation before the individual goes to sleep. But poisons do not act in the same manner on every individual. With some people their action is reversed. For example, opium may keep a patient awake instead of producing the much needed and longed-for sleep. In these cases the period of stimulation is prolonged and the drug acts as a stimulant rather than as a depressor. Eventually the depressing stage is reached, for all stimulating drugs have a period of depression after the stimulating action has worn off. Fatigue usually acts as a depressing poison and the period of stimulation is short. During this stimulating stage the individual gradually becomes able to work more

efficiently. He may be compared with a gasoline engine. The engine has to be warmed up before it works at its highest efficiency. The same applies to a person or animal. For example, a race horse is exercised before he enters a race. The boxer or a prize fighter punches the bag before he enters the ring. We can all work better after we have labored for a few minutes, but soon one reaches his best and from then on until he rests the amount of work that he can do is gradually decreased by the fatigue poisons until finally he becomes unable to work any more. In short, we may say that (1) fatigue poisons produce a short period of stimulation, and (2) they cause a period of decreasing ability, and (3) finally they prevent the further production of activity.

Fatigue affects first the kind and later the amount of work.—We have learned that fatigue is more than just a sensation—a feeling of being tired and unable to work—that it is a real loss of capacity or inability to do. In the beginning this loss of ability is qualitative. We become unable to do as good work. We make more mistakes. Dressmakers drop their stitches; typists strike the wrong keys; postmen can not judge slight overweights of letters; shades of color are told only by increasing the amount of light. The poet Goethe noted that the yellows turned to violets, oranges to blues, and reds to greens on fatigue. Baseball players make "bonehead" plays. With a greater amount of fatigue, the loss in capacity or ability becomes quantitative. We are unable to do as much work. There is a general slowing up. The runner has to slacken his speed. The attention becomes weaker and the personal equation increases. Gradually less and less work can be done until finally, if a rest period it not taken, one becomes unable to do further work.

MENTAL VERSUS PHYSICAL LABOR.

Although fatigue arises from either physical or mental labor, there are other elements that must be considered. Mental and nervous effort is developed by release of energy. But the amount is very small. It has been found by careful experiments that the hardest kind of study uses up very little more energy (food) than just quietly thinking of nothing in particular. Physical effort, on the other hand, uses up great stores of energy. Physical labor is produced by the muscles of the body acting on the bones and the joints of the skeleton. We have learned that the muscle cells are really little furnaces that burn up food; that they release energy, heat, and motion; and that they release waste products. In physical exercise, then, large quantities of oxygen must be taken into the blood through the lungs, large quantities of digested food must be delivered, and the waste materials must be gotten rid of. With the tuberculous person this large production of physical energy is a hardship because his general condition is weakened. His digestive system is impaired; his respiratory system is damaged; his heart muscle is weak; he is limited in his capacity to build up and to replace these large stores of energy; he is in danger of overloading his system. Besides, his health hazard requires that he do less than he is able to do.

Fatigue resulting from physical labor.—We will study first the general effect of fatigue as it results from physical labor. Later we will consider its local action in the muscle cells. Severe physical

effort impairs one's ability to think. Mountain climbers tell us that they remember very little of their trip and of the scenery at the top of the mountain. In order to recall facts about their trip they find it necessary to take notes. Football players after a hard practice game go to sleep while trying to study. An Italian professor by the name of Gibelli told Professor Mosso that when he became tired on a trip gathering plants for study in his classes he had difficulty in recalling the scientific names of the plants.

We will now consider the local action of fatigue as it develops in the muscle cell. Fatigue is not produced alone by fatigue poisons, but it results in part from exhaustion of the muscle cells. The muscle cell does its work by using up its own substance. It has the power to break up energy-containing matter, which comes to it by way of the blood, but it can do this only after it has taken up this energy and made it a part of itself. A muscle cell can not liberate energy until it has been stored in the cell substance. The muscle cell in a state of rest is alkaline in reaction like the blood itself. The cell, on the other hand, gradually becomes less and less alkaline as it works. and as a result the muscle cell becomes less and less sensitive to nervous impulses. When not fatigued the muscle cell is able to shorten or contract about one-fourth of its length. Not only is it able to contract, but it relaxes readily and returns to its resting state. As it becomes fatigued, the muscle cell finds difficulty in relaxing and lengthening after it has contracted. If one will grip hard with his hand on a stick for a few minutes he will find that after he has released his fingers from the stick, they have a tendency to remain closed. This condition is local. It is due to the increase in waste noted by a decrease in alkaline reaction and to the decrease of energy substance in the cell. If one has been in an unusual position for some time, as bending over and stooping, one experiences great difficulty in straightening up—the muscles that held one bending or stooping do not relax easily. This difficulty in relaxing is due to fatigue. This characteristic of the tired muscles to relax with difficulty is termed contracture. It is characteristic of tired muscles and is greatest in those which are most fatigued. In severe conditions it results in a disability as is noted particularly in writer's and dressmaker's cramp. In these cases, the muscles of the fingers have become chronically fatigued. For this reason any use of the fingers brings on a very painful and disabling condition. Mild contracture interferes with a person's skill in doing his work because, as we have learned, muscular action is performed by antagonistic groups and not by any single group. Contracture interferes with the friendly opposition of the muscles. Because opposing muscle groups can not relax easily and readily there is a lack of coordination and movements become awkward and clumsy. Hunters can not shoot as accurately; men working on machinery become less skillful and are more often injured. For example, it has been found that in factories a short period of rest in the middle of the afternoon increases the amount of work produced during the next two hours and reduces the number of accidents. It has been found that massaging of the muscles is helpful in reducing the amount of contracture, because it aids the blood in its removal of waste products and in supplying the muscle cells with food and oxygen.

LAWS OF LABOR AND FATIGUE.

In the doing of work there are five factors that must be considered: (1) The muscular system, (2) the nervous system, (3) the respiratory system, (4) the circulatory system, and (5) the digestive system. Labor must harmonize itself with the capacities of these systems. Not to do so brings on disorder and fatigue. The problem before us is, how may one expend his physical resources to the best advantage.

The following laws are a summary of the general principles governing labor and fatigue. These laws were evolved by Chaveau and Mosso.

Law No. 1.—The amount of fatigue developed by doing work depends on (*a*) the effort put forth, (*b*) the length of time in the effort, and (*c*) the amount of shortening of the muscles.

In other words, the muscle becomes fatigued in proportion to how hard it works, how long it works, and how much it has to shorten. One can readily understand that a muscle becomes tired faster at hard work than at easy work; that it becomes more tired in working five minutes than in working one. If one will stop to think, he will see why it is easier for a muscle to do work when slightly shortened than when greatly shortened. For example, it is easier to run a wheelbarrow with the arms at full length than it is when they are partly bent.

Law No. 2.—Every different kind of work has its physiological speed (rate) and effort (load) which should be determined by experiment, for the maximum of work and for the minimum of fatigue.

For example, the hod carrier should carry a load that is suited to his strength, and he should walk at proper rate. By overloading and a too rapid rate of walking he soon reduces his strength and hastens his fatigue.

Law No. 3.—Work done by a muscle already fatigued acts on that muscle in a more harmful manner than a heavier task performed under normal conditions.

This means that the interval of rest between one effort and another should be longer as one becomes tired.

Mosso in his work on fatigue has shown that a muscle completely fatigued by work returns to normal in about 2 hours. At the end of 2 hours it is able to do as much as it did before. If, on the other hand, a muscle does only half as much it returns to normal and can repeat its task after 30 minutes' rest.

THE ART OF LABOR.

In 1907 Professor Amar made a special study of walking and the carrying of burdens. In his work he employed hundreds of workmen and soldiers during a period of several months. He found that in walking on the level a most economical rate of travel is 4.5 kilometers (2.8 miles per hour, and that a man without a load, with a two-minute rest period at the end of each kilometer, could cover from 45 to 50 kilometers (28 to 31 miles) in a day. He found that a man carrying from 20 to 22 kilograms (44 to 48.4 pounds.) can most economically travel at the rate of 4.2 kilometers (2.6 miles) an

hour. Where it is necessary to work a man to capacity—that is, to have him do the most work that he can do in a day—he should be given a load of 45 kilograms (99 pounds); he should travel at the rate of 4.8 kilometers (3 miles) an hour; he should be given a rest of two minutes at the end of every 600 meters (650 yards) and the day's work should consist of seven and one-half hours of effective labor. He found that an average adult from 25 to 40 years of age can carry this load of 99 pounds for 26 kilometers (16 miles) per day. But he discovered that if the pace is increased to 5.5 kilometers (3.4 miles) per hour, the distance traveled would be reduced by almost one-half, no matter how the intervals of rest were arranged. He found that for the foot soldier "It is best to give him a total burden (pack, etc.) of 30 kilograms (66 pounds), while his normal pace should not exceed 5 kilometers (3.1 miles) an hour." He found that in bicycle riding the most economical rate of travel was 16 kilometers (9.94 miles) per hour. In agricultural labor he found that in shoveling the spade or shovel should weigh 1.7 kilograms ($3\frac{3}{4}$ pounds), that loaded it should not weigh more than 10.25 kilograms (20.55 pounds) at the most, and that the effort of putting the shovel into the earth should average 13 kilograms (28.6 pounds). In running a wheelbarrow a load of 100 kilograms (220 pounds) can be taken. This should cause a weight of 20 kilograms (44 pounds) on the two arms and the resistance in running the wheelbarrow should not add over 8 kilograms (8.8 pounds). He found that it was an advantage to have a two-wheeled barrow.

Professor Amar found, after extended experiments in the handicrafts, that a good workman, skilled and well trained in metal craft, worked with great regularity; that every motion occurred in rhythm and varied but little from the preceding movement. He discovered how a man should stand for filing metal. His experiments showed that the man should stand without awkwardness at a distance of 20 centimeters (8 inches) from the vise holding the metal; that the vise should be at the level of his navel; that he should stand as illustrated in the diagram; that the left hand should be completely extended and should press upon the file rather more heavily than the right arm; that they should bear down with a pressure of $8\frac{1}{2}$ and $7\frac{1}{2}$ kilograms ($18\frac{3}{4}$ and $17\frac{3}{4}$ pounds), and that the the return stroke of the file should consist of a simple movement without pressure, and that the rhythm of movement should be 70 per minute. He determined that five minutes' work should be followed by one minute of repcse or rest, the arms falling to the sides. In a good workman he found that 600 grams (1.32 pounds) of filings were made during a day consisting of seven hours of effective work.

To review, we may say that Professor Amar determined that trained men do more work and become less tired than untrained men because they know how to work; that is, they know the rate at which to work, the amount of effort to put forth, and when to rest. It is not sufficient, for example, that a man learn how to make furniture or machinery, but he must learn how to regulate his speed, how to stand, the length of time he should work, and when to take rest periods. An illustration will show the importance of a knowledge of fatigue and the results from failing to properly regulate rest, load, and rest periods. It is probable that the German Army

would have won the first Battle of the Marne and with it the World War if they had observed the laws of labor and fatigue. In their haste to invade France, through Belgium, the German general staff drove its troops to the limit of their endurance and beyond their resistance to fatigue. Day after day the troops were marched to their limit and their rest at night was unable to overcome the fatigue of the previous days. They reached northern France and the Marne in a condition of chronic fatigue. The result was that at the Battle of the Marne they were no match for the fresh French infantry carried to the battle ground in taxicabs from Paris. So we see the failure to observe the laws of fatigue and carrying burdens as established by Amar, noted above, really determined the history of the World War.

Chapter VIII.

MENTAL LABOR.

THE NERVOUS SYSTEM.

We do not know how, but in some way that part of us which feels, wills, and thinks—the nerves, spinal cord, and brain—regulates, governs, and rules the other parts of the body; for without orders from the nervous system the muscles can not work, and the heart would stop beating, and the body would be lifeless. We know that the different parts of the body are connected by the nervous system and that nothing goes on without the news being carried to the brain or spinal cord. The nervous system makes for order. Its control is developed by training; it is most wonderful. It can be made the last word in efficiency. Mind controls matter, but it does it through the nervous system, and one's efficiency depends upon his knowledge of the laws governing the nervous system, and the use he makes of them.

THE MIND—FUNCTIONS.

Memory.—Memory is the ability to recall to mind sensations and ideas that have been stored away. All the qualities of the nerve cell or neuron are made use of, but the main element in memory is that special quality of the neuron to become modified or changed and to stay changed after it has been modified. The act of memory is composed of four elements or parts. There is (1) the element of receiving, (2) for storing away, (3) for finding again, and (4) for recognition. The knowledge of these four elements or phases of memory and the practical use of them will aid one in his studies. It is important that which one wishes to remember is received clearly and that it is understood. If the nerve messages from the nerve endings of the eye or ear are not definite and clear, the vision and the hearing centers only receive a blurred impression which has a tendency to quickly fade away.

One should seek to have the sensory impression from the nerve centers received in a clear and orderly manner and by that center that functions the best. Some remember better that which they have seen: some better what they have heard; some by seeing and hearing together. In your own case you should know how you remember best. Do you remember things by sight or sound? When you recall a thunderstorm, do you see the lightning and do you hear the thunder roll? If you only see the lightning and do not hear the thunder, it is evident that you remember better what you have seen than what you have heard. You may find that by a combination, as by reading aloud, you are able to remember better. It is advisable for you to find your best method and use it. You can with effort develop either the vision or the hearing method. But the older you are, the more difficult it

becomes, and usually for the adult it is not worth while to change. It is best to develop your most efficient method. The storing-away phase of memory is based largely upon the quality of modifiability—that is, the change made in the neurons. This ability is largely a matter of inheritance, but the whole function of memory can be made more efficient by painstaking effort. When one wishes to memorize facts, figures, dates, multiplication tables, or poetry, he usually does it by repeating—repeating—until they can be recalled. But how can repetition be used to the best advantage? For example, suppose one should wish to learn 100 lines of poetry, and that it would take 30 repetitions to fix them in mind. Should one repeat the 100 lines 30 times in one day, or should he repeat them once a day for a month? It has been found that usually it is more economical to spread the repetition over several days, because the law of association unconsciously aids in memorizing through the association of ideas. It has also been found that new connections or associations occur when one's thoughts are on other things. In memorizing, always try to connect up what you are trying to learn with something that you already know. If you can make such an association or connection you have greatly lightened your burden. Another element in memorizing is that of interest or zeal. People memorize more easily facts that they are interested in. For example, it is not unusual for a boy to know the batting average of all the leading baseball players in the country, while his knowledge of the multiplication table or of current events may be very deficient.

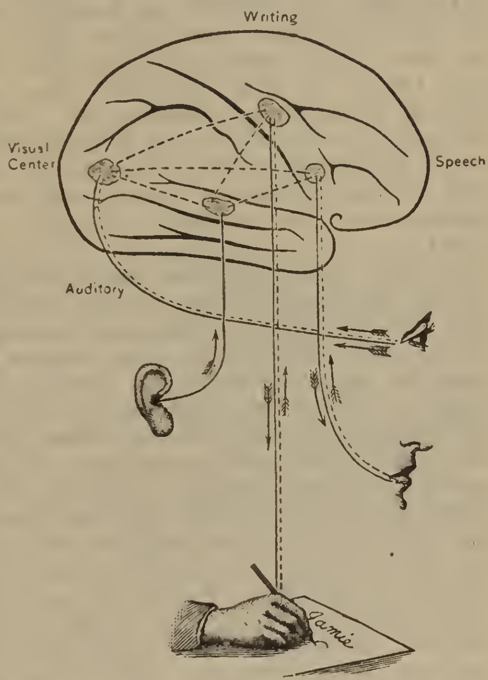


FIG. 91.—Connection of brain centers by association fibers. (After Landois and Stirling.)

Habit.—The nervous system is so arranged that there may be a great economy in effort. The first time an act is performed it is hard and difficult. The forebrain must give it close attention. But with every repetition of the act it is repeated easier, for the nerve currents flow more readily and finally the act can be performed without any attention from the forebrain. Action that is done without thinking—that is, without giving attention—is called reflex, or automatic. As examples we may take piano playing or typewriting. In either case the necessary muscular actions become so natural that the typist or the player can perform with very little or

no attention. This quality is the basis of habit. Habit may be defined as the tendency to do things the same way every time. Man is said to be a "bundle of habits." Whether we will or not, we are continually forming habits for our good or our ill. Because of their pulling power, habits may be a help or a harm: a benefit or a source of evil. Habits come from that quality of the nervous system which always seeks an outlet in action for every nerve current. Every sensation, every feeling, every idea, pushes forward until its nerve currents escape in some movement. It has been found that if a person while standing will think of something at the right of him, he will move slightly in that direction. Even when one reads quietly the muscles of the throat and tongue are found to move. It follows then that one should use great care that the right movements—motor outlets—are made. Ever effort should be made that the first time an act is done that it be done correctly. This applies especially in piano playing, typewriting, speaking, etc. Nerve currents tend to follow old paths, for the conducting neurons offer resistance and this resistance is greater over new paths. Nerve currents that bring about the same act smooth the way for the next nerve current until finally the resistance to a nerve current necessary to do any act is much reduced.

We learn to do things by effort—hard work. But we receive our reward, for when we have learned how to do an act it is done with ease. The fore-brain is then able to turn over the doing of the act to the part of the brain that controls automatic action. It may then give its attention to new duties. Think of what a saving or economy this is. It is the basis of training. Without this ability, life would be one continuous burden. We would never be able to do anything with ease or accuracy. We should never be able to do anything without paying the closest attention. For example, we would not be able to walk about and think of other things as we are able to do now. All our thoughts would be used up trying to walk. But like all the laws of nature, which if neglected result in harm, so the laws of habit. Bad habits are just as easily formed as good ones, and they have a way of coming back when not expected or wanted. Habits are more easily learned in childhood or youth. Man is a creature of habit. Everything that he does is influenced by what he has done before. The stain always remains, like the telltale ink blot. Education is really the development of efficient habits. Another reason why one should have good habits is that nerve currents, like persons, travel more easily on old paths. They go the easiest way if not made to go differently. As we have said, it is possible to change habits, but it takes effort. It is easier to float down the river than it is to row up stream. Bad habits may be turned into good ones by the following method:

1. Make a good resolution. 2. Make an emphatic start. 3. Never permit an exception to occur. 4. Seize every opportunity to act on your good resolution.

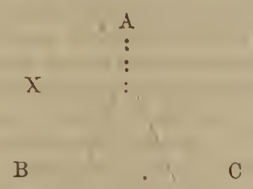
In this manner Doctor Kitson lists the steps for the development of the formation of habits.

To change a habit or to develop a new habit it is necessary in the first place to make up one's mind; that is, to decide or determine to do something. (2) Next, the determination must be put into ac-

tion; this action should have an emphatic start. For example, suppose one wishes to break off smoking. An emphatic start can be made by throwing away one's tobacco. Tell your friends about breaking off and wager someone $5 that you will not smoke for a month. In other words, try to make it as hard as you can for yourself to fail. (3) Don't let yourself slip for even one time. Just one smoke and you have failed.

Dr. Kitson in his book of "How to Use Your Mind," says:

Never permit an exception to occur. Suppose you have a habit of saying "aint" which you wish to replace with a habit of saying "isn't." If the habit is deeply rooted, you have worn a pathway in the brain to a considerable depth, represented in the accompanying diagram by the A X B. Let us suppose that



you have already started the new habit, and have said the correct word 10 times. That means that you have worn another pathway 10 times. That means that you have worn another pathway A X C to a considerable depth. During all this time, however, the old pathway is still open and at the slightest provocation will attract the nervous current. Your task is to deepen the new path so that the nervous current will flow into it instead of the old. Now suppose you make an exception of some occasion and allow the nervous current to travel over the old path. This unfortunate exception breaks down the bridge which you had constructed at X from A to C. But this is not the only result. The nervous current, as it revisits the old path, deepens it more than it was before, so that the next time a similar situation arises, the current seeks the old path with much greater readiness than before, and vastly more effort is required to overcome it. Some one has likened the effect of these exceptions to that produced when one drops a ball of string that is partially wound. By a single slip, more is unwound than can be accomplished in a dozen windings.

(4) Seize every opportunity to act on your resolution, for the nerve currents seek an outlet in activity. Habit is their usual or easiest outlet. A new habit is established when a new easiest outlet in action is made for the nerve currents.

HOW TO STUDY.

The tuberculous man who is taking up training is confronted by the problem of how to study. He must learn to use his mind with efficiency, without loss of time or energy. It has been found that the mind has definite laws and that definite rules may be followed which will help very materially in one's mental effort. A little study of how one's mind works brings out the fact that there are several things, ideas, sensations, desires, etc., in the mind at the same time. But only one of these has the spotlight, the others are more or less in the dark, and one is only partially conscious of them. Just as the spotlight follows the actors about the stage, so attention follows ideas and keeps them in the center of the mind, so to speak. We have learned that nerve currents seek outlets in motion or activity. Thoughts are always in motion; they can not stand still. Thoughts on the edge of the mind either pass toward the center and crowd away the thoughts

in the center, or they pass out of consciousness. We see then that it is necessary to make use of thoughts in motion by doing something with them; by keeping them active we are able to keep them in the center.

Distractions.—When trying to study, other ideas and sensations have a tendency to crowd in. Because they interfere with study they are called distractions. Distractions come from three sources: (1) Bodily sensation, such as discomfort, fatigue, eyestrain, headache, tight clothing and shoes, heat or cold, etc. (2) External sensations, as noise, radiators pounding, typewriters clicking, the music of phonographs, etc., talking and the like. (3) Ideas, as thoughts of going home, compensation, expenses, or of the dance to be given next week. Much can be done to prevent distracting bodily sensations. It is important to get an easy-chair and seek a quiet room. The temperature should not be too hot or too cold. It should be about 68°. The light should be good; for writing it should come over the left shoulder, so as not to cast a shadow; it is advisable to rest the eyes frequently by closing them for a moment or two, and every half hour or so get up and walk around for about two or three minutes. Do not try to study where it is noisy, or where you will be disturbed by others talking. Some noises can not be eliminated; make up your mind to study and put away all other ideas. Do not let your thoughts wander. Keep them busy on what you have to do. Do not let them loaf or "gold brick" on you, and seek that frame of mind where thoughts going A.W.O.L. will remind you that your attention is wandering and will help you to bring back your attention to what you are studying. It has been found that thoughts have a tendency to go A.W.O.L. when one does not understand what he is studying or reading. If you do not know the meaning of a word, look it up in the dictionary. It is well to get the dictionary habit. At the beginning of your study you will find yourself more or less out of the habit of controlling your mind—that is, keeping it on any one thing to the exclusion of other things—but do not get discouraged. Determine to develop good study habits. You will find it difficult at the start. You should not expect too great improvement. A little every day is sufficient. It means work and self-denial, but it is worth while. It is necessary for you to develop your mental and nervous power to take the place of your muscle power; you should become a mental worker. A tuberculous man can not be a beast of burden and keep his health.

How to use your mind.—This is the day of the $10,000 man. Such a man is always in demand. When one is in that class he never need be out of a job. Why is a man paid $10,000 a year? It is because his ideas are worth money. He can get around difficulties; he is able to solve business problems; he knows how to use his mental powers; he thinks before he acts. Confronted with a business problem, he uses all his mental resources; he puts his mind to work; he calls on his memory for former experiences and facts stored away. Memory is quickly able to gather these experiences and facts which are useful and necessary for the solving of the problem, because they have been classified and indexed. His mind works with order and system. He does not overlook facts and conditions. His answers are always right. He does not make "bonehead" plays.

Do not use your mind simply as a storehouse. Watch what comes in. Do not believe everything that you see and hear. When you read, ask yourself questions. Seek to know the why of things. Suppose you read that all large cities are located on large bodies of water or rivers. Ask yourself why is this. Your ability to find out the why of things is an index to your mental power and value. It is not the amount of knowledge that you have, but the use you make of it. What you know but can not use or do not use is of little value. For example, a person needs a saw. He owns one, but if he can not find it when he needs it, the fact that he owns a saw is of no value. Thoughts are mental tools, and, like tools, they must be taken care of. Every tool has its place and must be kept sharp, ready for use. Memory keeps your thought-tools ever ready. Use of your thought-tools keeps them sharp. It will help you to think of your mental work as an effort to solve problems. The right answer to your problems means success in your school work and on the job.

How may one develop his mental power?—Clear thinking is a matter of habit and effort. Study to know well that which you know. Can you tell others what you have in mind? A study of definitions will help you. Definitions are really short cuts. They are condensed knowledge. As one can save time by cutting across lots, so one can make mental crosscuts by learning definitions. Besides this, definitions help in classification. Classification simply means order, a place for things and a system for joining and connecting together similar ideas and thoughts. The solving of mental problems is not guesswork. It may be divided into three parts. First, the recognition that one has a problem to solve; second, getting the facts together to solve the problem; and, third, the feeling that one has reached the right answer. To begin with, one must recognize that he is in a situation that he must get out of, like the heroine in the movie play. For example, one's auto stops on a country road and refuses to start. It is clear that one is confronted with the problem of finding out what is wrong with the engine and why it will not run. We call to mind other accidents and the causes of them. We remember that once the spark plugs played out. So we test them. Again we remember that dust got into the carburetor. So we test it. We go on calling up possible causes and try to remedy them until we find the difficulty and the engine is started. (Kitson.)

When one is beginning again his study habits after having been out of school for months or years, he may find that he has to go slow; that he soon tires; that he gets nervous and just can not make his mind work right. This difficulty is to be expected. It is always harder to do things that one is not accustomed to do, and as we shall find, more fatiguing. Just as a prize fighter must go into training and gradually build up his muscles and wind, so one must gradually develop his nervous system and mental power. By taking little short rest periods of from two to five minutes, one is often able to get over that nervous feeling and can go back to his studying. That restless feeling is nature's way of saying that we are going too fast and that a rest period is necessary. Short rest periods every 20 to 30 minutes will often enable one to continue his work, where if he did not rest he would be compelled to stop entirely.

THE USE AND CARE OF THE NERVOUS SYSTEM.

Fine instruments, like watches, easily get out of order and have to be repaired. Cutting tools, like razors, readily become dull and have to be sharpened. As the nervous system is the most complicated part of the body, it is the first to fall into disorder from injury or bad usage. The brain, spinal cord, and larger nerves have been so located and surrounded by bone and muscle that they are all protected from ordinary injury. The nerve endings, however, are not protected, for they serve as outposts and sentries. They are always on guard to forward news to the central nervous system. The nerve endings, as we have learned, are located in the skin, eyes, ears, mouth, and nose, and continually, asleep or awake, they send in nerve impulses which keep bombarding the nervous system. It is important to bear in mind that nerve impulses once started seek to keep on going until they gain an outlet in action. Dreams are explained on this basis. They are said to arise from sensations of noise, heat, and cold. One dreams of snow and winter because he is sleeping without enough coverings. So we see that although the nerves are protected from mechanical injury, they are not protected from their own activity, from nerve impulses arising from the nerve endings. The function of the nerve endings to the body is illustrated by the rapid movement that occurs when one touches something hot. The hand is rapidly pulled away before it has been burned. The nerve endings may be destroyed, but they have served their purpose and have protected the body from larger injury. The ability of nerve impulses to tire out and exhaust the nervous system by their continual barrage is illustrated by the effect of an aching tooth. The exposed nerve sends in its complaint—nerve impulses. These nerve impulses come in so fast and furiously that we think of them as pain. If neglected they affect us so strongly that we are wont to say that we are half sick. Nerve impulses from corns developed by tight shoes are another illustration. In either case, the pains (nerve impulses) are trying to tell that something is wrong and that it must be made right.

In perfect health there need be but little effort made to conserve one's nervous energy, as there is a reserve and new supplies are rapidly produced. But very few persons enjoy perfect health, and none should acquire habits of waste. In the beginning of ill health, when the body motor does not operate as efficiently, the first evidence of disorder is found in the activity of the nervous system. Patients traveling on the borderland between health and disease find themselves suffering from symptoms of neurasthenia, sometimes called "brain fag" or exhaustion. They are less resistant to fatigue; they tire more easily; they suffer from headaches; they are irritable; they feel all out of sorts; they are restless and do not enjoy taking up any kind of work. These symptoms are indications of nervous bankruptcy; they warn us that something is wrong, and to the tuberculous that there is a possibility of a relapse or loss of immunity. If it is important that the trained engineer observe his engine to note the first signs of disorder, and that the trained chauffeur be on the lookout for signs that his motor is not working efficiently and that he take steps to repair it, following the old adage "a stitch in time saves

nine." it would seem that the inactive tuberculous case should be trained to note symptoms of a breakdown and incoming disease. He may then immediately take steps to secure enough rest and other treatment to bring about a speedy recovery.

CONSERVATION OF NERVOUS ENERGY.

Nervous leaks.—The energy of the nervous system may be spent in useful or useless effort. We may think of the nonuseful use of nervous energy as nervous leaks. It is important that we know where these nervous leaks are and how we may stop them up. Just as one on a small salary with little or no money in the bank must economize, must reduce his expenses, so one with a poor nervous energy income must economize on his nervous energy outgo. He must count his nervous pennies, so to speak. During the hot and dry weather, when the city water system runs low, means are taken to conserve the water supply. Leaking pipes and valves are repaired and only certain hours are allowed for watering lawns, etc. Everything is done to save the supply of water for the strictly useful and necessary things. Similarly when one's nervous system has run low, when one's nervous income is reduced, it is necessary for him to stop his nervous leaks, to limit his recreation that he may have enough nervous energy to accomplish his useful and necessary work. For purposes of study, we may consider nervous leaks under three headings: (1) Personal (at home), (2) social and recreational, (3) industrial (on the job).

Personal leaks.—A large amount of nervous energy is wasted on account of ill-fitting and nonsuitable wearing apparel. Tight shoes, narrow skirts, because they necessitate short steps, not sufficient clothing to provide warmth for the body, or excessive clothing during the warm weather are some of the few causes of waste energy. One should avoid living where there are excessive noises, as street car lines; near railroad yards where trains are switching with loud bells ringing, whistles blowing, etc. It is also important that one's rest at night is not disturbed by crying babies, crowing roosters, barking dogs, and ill-sounding musical instruments. Another important source of nervous leaks is local disease, such as diseased teeth and gums, or affections of the nose and especially the cavities connecting with the nose. Diseases of the eyes, with inability to see properly, cause fatigue, due to awkward positions at work and, through the development of eyestrain, headaches.

Social and recreational leaks.—It is important that one should avoid recreations that use up excessive amounts of nervous energy. If one is in the habit of retiring at 10 o'clock and stays up until 12 or 1 a. m., it means more than two hours or more of nervous energy. The spending of nervous energy after one is tired and after his usual time for going to bed, as we will learn, is much more harmful than spending that same amount of time during the day. Emotional outbreaks, losing one's temper, tongue lashing, worry or fear, etc., causes an immense amount of nervous waste. They are bad, not only for the individual, but they are injurious to one's associates. One should study to acquire a friendly and pleasant attitude toward others. He should control his own emotional state. Worrying over social position, being sensitive and jealous, are more exhaustive to one's nervous system than one would think.

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Industrial leaks.—They will be only outlined here and considered more in detail under the subject of "The T. B. and His Job." In general, industrial leaks may be thought of from the standpoint of (1) the human element, (2) place of work, and (3) kind of work. The human element may be a great source of nervous waste. Nagging, bluffing foremen, and fellow workmen and associates cause severe nervous leaks. When there is a friendly, cooperative attitude between employers and employees and among the workmen in the factory and in the office, the amount of nervous energy that is wasted is reduced to the minimum. It is important that the place for work have the right kind of environment; that is, that the temperature, humidity, ventilation, and light be satisfactory. Dust, excessive heat or cold, poor light, and a constant din are sources of nervous waste. Persons vary greatly in the amount of nervous energy that they have to spend on doing any particular job. A job that is easy for one may be very hard for another. It is important that the workman be trained for his job, and that his routine actions be automatic. In short, the job must be suited to the man and the man to the job, to reduce nerve leaks to the minimum.

MENTAL ACTIVITY—HOW AFFECTED BY FATIGUE.

In our study of the nervous system we considered the functions of the mind—as attention, memory, habit, etc. We took up habit formation and the relationship between attention and the power to study, and we made some practical applications—uses. We will now take up a study of the relationship between mental effort and fatigue.

Nervous energy.—In our study of fatigue we have learned that it is noted in two ways, local and general effects, and that the general effects are the same in mental as in physical effort. We recall, however, that there is a decided difference between the amount of energy released in mental effort and that in physical effort; that physical activity consumes large amounts of energy, while mental activity uses such small amounts that it is only recently that these amounts have been measured. It has been found in recent years that nerves take up oxygen, give off CO_2, and that nerve tissues are especially susceptible to the influences of CO_2; that nerves exposed to CO_2 lose their power of irritability—that is, the ability to receive impressions, though they can conduct them. For example, if part of a nerve is exposed to CO_2, and part to the oxygen of the air, the part exposed to air can receive impressions, but the part exposed to CO_2 can not. However, the impressions received by the part exposed to air can be conducted through the part exposed to CO_2. It has been found that the neurons of that part of the spinal cord of the honey bee which supplies nervous impulses to the wings is very much changed by the bee's work in gathering honey. In the evening certain parts of the neurons are reduced to one-fourth the size they were in the morning. These parts are less solid and more liquid. These observations indicate that there is combustion and release of energy in the nerve cells. The combustion in the neuron is probably rather of protein than carbohydrates and for that reason it produces very poisonous wastes.

It was Mosso's conclusion, after years of study on the subject of fatigue, that fatigue arises almost, if not entirely, from nervous

activity. This conclusion is not unreasonable, as all physical—muscle—activity depends upon nervous impulses; that is, nervous activity. The marked effect may be explained on the basis that while the combustion in the neurons or nerve cells is small, the effects are great because of the extreme poisonous nature of the nerve waste. For example, it is known that certain poisonous materials like those developed from tetanus (lockjaw) are very powerful and that even so little an amount as one two-hundredth of a grain may be fatal.

Fatigue from mental effort.—As has been noted before, fatigue is usually thought of as a sensation rather than as inability to do mental or physical labor. The sensations arising from mental fatigue may be summed up as follows: At first there is a slight indifference and unwillingness to continue the task. A little later there is a desire for a change, followed by a feeling of dullness, a feeling of inability to do the work, though we wish to continue. This feeling of indifference changes to weariness and headache develops irritability and a change of disposition; the head feels heavy, the eyes become bloodshot, with vision less acute and blunting of the other five senses; like the drunken man, there is lack of inhibition, a restlessness, and a false condition of excitement. These latter are rather objective signs of sensation and indicate that fatigue impairs the ability to do. Fatigue from mental effort, as from physical effort, has local as well as general effects. The local effect has for its purpose the protection of the working cells. The general effect has for its purpose the protection of the body as a whole from overactivity. When one is fatigued from mental effort, a change to physical work is not sufficient. When we are all tired out, we can not rest by taking up a different kind of work. Mosso says that he walked like a weary laboring man when he was tired out by pure mental effort. It has wrongly been taught that when all tired out with mental effort one can rest by taking up physical exercise. One must not conclude that physical exercise is not of value to the mental worker. It means that physical exercise does not rest one when he is tired out from mental work. It is necessary that he take a period of rest and later when refreshed he is ready to take up some physical exercise to advantage. Mosso, the great Italian physiologist says that neurons tire out, become fatigued, very quickly, probably in three or four seconds, but as there are approximately two billion of them, as one group of neurons becomes tired it is replaced by another. These replacements allow for alternating periods of activity and rest and permit us to carry on a mental effort without rest for long periods of time. But one must be trained, the replacements must be automatic. Some people, are more susceptible—easily influenced by mental effort; they tire very quickly. Mosso in his book on fatigue says that it is reported that when a group of Seminole Indians in Florida were questioned by some of the earlier explorers, the Indians after a short period of time showed distress and weakness with other signs of extreme fatigue. The Indians requested that they be excused from further questioning until the following year, when the explorers expected to return. Mosso seeks to explain this marked susceptibility to fatigue by saying that the Indians were not in the habit and had not been trained to continuous mental effort.

The qualitative and quantitative change.—Fatigue changes first the quality and then reduces the quantity of mental work. Psychologists—those who study the mind—and physiologists have found ways to determine the kinds and amounts of fatigue present. By carefully studying the functions of the mind, the determination of the personal equation and nerve reaction, they have found that the first effect of fatigue on mental activity is to reduce the quality of the work. There is a qualitative change in one's work. The school boy can not spell as correctly in the late afternoon when he is tired as he can in the early morning when he is fresh. The translation of foreign languages becomes more difficult with a greater number of errors. Later on fatigue causes a quantitative reduction as well as a qualitative change. One becomes unable to do as much mental work. The attention is weakened and the rapidity of thought is decreased. One's thoughts and ideas travel at a decreased rate of speed. The personal equation is lengthened. The stenographer can not take as many words to the minute. There is a general impairment of mental activity. The quality and order of ideas are impaired. The writer hesitates. The self, the ego, seeks more frequently to gold brick and go A. W. O. L. Fatigue affects first the highest function of the mind, the judgment, the power of attention, and the emotional control. It has aptly been said that fatigue consumes the highest qualities of the mind.

Work fever.—It was noted in our study of the physical work that when one begins to work he can not work as well as he can a little later when he gets into the swing of it. It is necessary that one get into the spirit, zest, or enthusiasm for doing mental work. This condition is sometimes spoken of as "work fever." During this condition one is able to do his best work, both mental and physical. Mosso found by the use of the ergograph that Professor Aducco was able to do more physical work on lecturing day than he was on a day when he did not have classes. It is necessary to point out, however, that this enthusiasm, this "work fever," increased the development of fatigue, because one is working at a higher pressure. It is important that one learn to adapt the amount of his "work fever" to the class of work at hand and that for unimportant work he should not use any at all. In this case it is well to note that one should plan one's daily tasks—one's study and recreation—according to the development of one's fatigue. The hardest and most difficult tasks should be accomplished in the morning. A person should plan to do simple and easy jobs in the afternoon, when he can not do as good work and when he is more likely to make mistakes. The stenographer, for example, should have her dictation given her in the morning, so that she may write her letters in the forenoon and early afternoon. Her filing and routine work should be done in the late afternoon, when she is more fatigued. It is poor business management to allow her to do simple routine work in the forenoon and then work her at high speed and tension in the afternoon in order to get her letters out for the evening mail. In the afternoon she works with greater effort to accomplish the same amount of work and she can not help but make more mistakes than she would have in the forenoon.

FATIGUE PREVENTION—A SUMMARY.

As we have learned, the amount of work that one can do depends (1) upon his resistance to fatigue, (2) his knowledge of how fatigue develops, (3) how it may be delayed, and (4) the practical use that he makes of this information. It is our purpose to review and sum up all the factors that increase fatigue and those that reduce it. We have learned in our study of habit that nerve impulses seek to travel along old, well-worn pathways because they meet with less resistance. One hundred years ago it was a long, tiresome, and fatiguing trip from Washington to Chicago. The trip lasted from 1 to 2 months. Now one can travel from Washington to Chicago in less than 20 hours in comfort, with ease and with little fatigue; but it took millions of dollars and years of effort to make possible this trip of less than 20 hours to Chicago. Likewise one may travel the pathways of the mind with comfort, with ease, and with little fatigue, but only after years of training and effort have prepared these pathways for efficient mental work. You will recall that the acts performed by the hind-brain are more easily accomplished; that when we have learned to do anything with ease, it is turned over to this part of the brain. The acts performed by the hind-brain are spoken of as automatic because they do not require attention from the fore-brain. It is important that just as many as possible of one's daily tasks be made automatic—dressing, eating, cleaning of the teeth, bathing, etc., that is, should be done without conscious effort. During these acts the mind should be free from the problems of the day. For example, the great Greek philosopher, Archimedes, discovered the great principle of natural science, specific gravity, while bathing. As his attention was not taken up with this routine task, he was free to consider the laws of nature.

Training, system, and good health increase one's resistance to fatigue. Lack of training, disorder, loss of sleep, worry, blues, depression, etc., increase and hasten the development of fatigue. Efficient work depends on three factors: The amount of the load, the rate of speed, and rest periods. Each of these factors is like a link in a chain, and the old adage, the chain is as strong as its weakest link, is applicable. One's efficiency depends upon the weakest of these factors. For the release of energy all the great systems of the body are involved and one's ability to release energy is dependent upon each and every one. It is important, therefore, that one does not overload. (1) He must learn his optimum load—that is, the load that he can carry to the best advantage; one that is not too heavy nor too light. For a heavy load quickly brings on fatigue, while with a light load one does not accomplish as much as he should—that is, in either case the load would not be economical. (2) It is just as important that one learn his optimum speed—the speed that for him is most advantageous, not too fast nor too slow. (3) It is important that he observe rest periods. Life goes on in a state of rhythm or waves, in ups and downs, and just as one can not have mountains without valleys, so one can not have activity without rest.

PART III

TUBERCULOSIS AND EFFICIENCY.

Chapter IX.

RESISTANCE TO DISEASE GERMS—IMMUNITY.

GERMS.

Cause of disease.—Diseases result from various causes, as injuries, poisons, disease germs, and, during old age, disorders of the internal organs. It will be necessary for us, however, to pass over the other causes of disease and consider only how disease germs bring about disease and how the body and its cells defend themselves from these germs. We have learned in our study of the white blood cells that they are able under some conditions to take up and destroy germs. It is believed that during disease there is formed in the blood something that helps the white blood cells to take up and destroy the germs. We have learned that these white blood cells are able to wander out of the capillaries and that in local infections, like a boil, they are found outside the blood vessels in great numbers. The white blood cells in such infections are a part of a defense put up by the body which is, in part, a local resistance in the fixed body cells as well as a resistance in the blood. In other words, one may say that resistance to disease germs comes from two places—(1) the blood and (2) the body cells. To make it more clear, one may say that during disease there are created in the blood what are called antibodies; that is, bodies that actively resist disease germs. These act mostly chemically. Secondly, the body cells by means of inflammation and fibrous tissue formation aid in stopping the spread of disease germs from that part to other parts of the body. This action is mostly mechanical.

Kind and composition.—Germs are living cells. They need and use energy. Most of them get their energy, like body cells, by the combustion of food and gaseous oxygen in their cell substances. They may be either plants or animals and their general habits and properties are similar to those of a one-cell plant or animal. Germs may be divided into three groups—beneficial, harmless, and disease producing. As an example of the beneficial type of germs, we have those that inhabit the soil and fix in the soil the nitrogen of the air so that it may be available by certain kinds of plants, as beans, peas, and especially alfalfa. Without these germs, alfalfa can not grow. Most germs are harmless so far as the body is concerned. For example, the colon bacillus in the large intestine is harmless except under unusual conditions, when it changes to a disease-producing germ. There are only a few disease-producing germs considering the many germs that have been found to exist.

Germs to be disease producing must cause in the animal certain effects and reactions. They must be able to get their food from the body cells by a process which is similar to digestion; that is, by ferment action. We see then that the ability to produce disease rests on the power of the germ to develop a ferment which can digest or break up the cells of the animal body in which they are growing. On the other hand, the body cells react and defend themselves against this action of the disease germs by developing, as we have learned, antibodies, part of which may be considered ferments and are able to destroy disease germs. Disease has sometimes been referred to as a battle of the ferments, but before discussing this battle it will be necessary to consider further our study of the germs themselves and the body's reaction to protein.

Germs are protein in their composition and, although they are alive, in dealing with them one may consider them as protein. This fact is important, for it has been found that in the digestion or the breaking up of proteins a poisonous part is split off. Every protein contains this poisonous part. Fortunately, further digestion splits up this poisonous part into more simple nonpoisonous parts or substances. Even in the stomach and intestines, this poisonous part of protein is developed, but except in unusual cases it is further digested and made harmless before it is absorbed. When a protein is injected into the blood stream or lymph, there is developed after a time the power to destroy that protein. Protein is the only substance that brings about this reaction, besides this power can not destroy any other protein. It has to be developed for each individual protein. In other words, it is specific, as for example, typhoid bacilli in the blood develops a resistance to typhoid bacilli but this resistance would not affect pneumococci. This resistance to disease germs as we have learned may be considered as partaking of the nature of a ferment and its action may be thought of as two parts—first, making the germs prisoner by sticking them together; and second, by killing them by a process similar to digestion. There may be some natural resistance, but usually most of the resistance to disease germs has to be acquired; that is, developed. When the disease germs enter the body, the person does not immediately get sick. Several days usually elapse before the individual becomes ill. During this period, his resistance—that is, the development of antibodies—develops and becomes stronger and stronger. When these antibodies or ferments become able to break up the disease germs in quantity, separating the poisonous part from the nonpoisonous part of the protein, the poisonous part causes the illness. The man stays ill until the ferment becomes so strong and rapid that the primary breaking up of the protein is followed immediately by still further breaking up of the poisonous part so that the poisonous part does not have time to be absorbed. When this has been brought about, the individual gets well, and from then on for months, or perhaps years, he is able to defend himself against any later invasion (infection) by this particular disease germ. Resistance to disease is a very complicated process. It is difficult to understand. There are many things that remain to be discovered and explained. The explanation given, it is believed, will help.

TUBERCLE BACILLI.

The tubercle bacilli are very difficult to digest and for this reason resistance against them is more successful when developed along mechanical lines. The body cells seek to arrest them so that they may not spread. We speak of this as localization; that is, the keeping of the tuberculous bacilli in one place. In the beginning this localization is inflammatory, similar to reaction around a boil. Later it develops fibrosis or scar tissue. Large amounts of this scar tissue are formed and years are spent in the walling off and the making of strong prisons for tubercle bacilli.

The tubercle bacillus is a disease-causing germ in man, mammals, and birds. There are three types—human, bovine, and avian. Tubercle bacilli may grow in any of the body organisms or tissues, but in the adult the germs seem to favor the pulmonary tissue of the lungs. The germ is slow growing. The fact that it grows slowly calls for a special defense or resistance. It is able to live in the animal body because the bacillus is protected by a fatty, waxy coat. This coat is very indigestible. Its defense may be compared to that of a porcupine or other animals which have protective skins or shells that aid them in resisting their enemies. The tubercle bacillus is a very tiny organism—small enough for several to ride easily on a dust particle waved by the breezes; small enough to slide down on a sunbeam. One should think of it as so small that it is invisible to the naked eye, to be seen only through a microscope after it has been stained or colored by a dye. (It is usually stained red.) One should picture it defending itself from hostile surroundings by its resisting armor, its fatty, waxy coat.

Origin of tubercle bacilli.—The origin of the tubercle bacillus is unknown. It has been said to date back to the time when man left his abode in trees and began to dwell in caves for protection against his enemies. The tubercle bacillus has developed its characteristics, its power of self-defense against body cells, to a high degree. This fight against mankind has been going on for centuries at least.

Life cycle of the tubercle bacillus.—It is not the intent (if one may say so, of course it does not reason) of the tubercle bacillus to destroy its host, for if it did it would destroy its home and its boarding place. The tubercle wants to secure the continuance of its species. To continue its species it is necessary that the tubercle bacilli pass through what may be termed their life cycle. In the first place the germs must gain entrance in an animal; secondly, they must develop and grow; thirdly, they must establish a passageway out of the animal by breaking down cells; and fourthly, they must survive the journey from their late home or host to that of another host. The families of tubercle bacilli that have survived down through the ages are those that have been successful in passing through these four stages. They have been successful because of great numbers of tubercle bacilli cast off from a tuberculous individual. Their number is innumerable, like the sands on the seashore. Until recent years, about one out of every ten individuals in civilization died with pulmonary tuberculosis. Two more suffer from tuberculosis as a disease at some time during life. The number of deaths from tuberculosis is rapidly decreasing in the United States. From this it is easy to understand that tubercle bacilli are very common, and how any person can have

escaped receiving the germs into his system until he is an adult is difficult to understand.

Evidence is at hand to prove that starting from birth to adult age every year an increasing number of persons are found to have been infected with tubercle bacilli. It may be assumed that in civilization by the time a person has reached 5 to 7 years of age he has usually had at least one and generally several infections with tubercle bacilli.

When tubercle bacilli first enter the body of an animal, their presence and growth irritate and soon stimulate the body cells to resistance. In the beginning the resistance is very weak, but this resistance gradually increases and within three weeks it has developed considerable strength; later infections serve to increase this resistance or relative immunity.

KOCH EXPERIMENTS.

Robert Koch, the discoverer of the tubercle bacillus, first performed or carried out these famous, the so-called Koch, experiments. He found that if one will inject tubercle bacilli into the skin of a healthy guinea pig, in the course of 10 to 15 days one may note a hard nodule arising which later on breaks down, and until the animal dies forms an ulcerating sore. In addition to this there is a spread of the germs through the lymphatics. These are little tubes leading to the neighboring lymphatic glands—the first defense to infection beyond the skin where the tubercle bacilli were injected. Following this primary injection no change is noted in the behavior of the animal. He is not and does not appear to be sick. If he is a growing animal his growth continues. In other words, the presence of tubercle bacilli in a nontuberculous animal does not give rise to symptoms until the animal has become tuberculous, and has developed certain specific qualities which enable him to act energetically against tubercle bacilli. If one will inject a guinea pig which has been injected with tubercle bacilli from four to five weeks previous, he will find a different reaction occurring. Following reinjection there is a more rapid reaction. The nodule comes up more rapidly; there is an alteration in the skin at the point of injection and for some distance beyond; there is a more rapid breaking down with unlceration; the ulcer has a tendency to heal, and there is no spread of the infection to the neighboring lymphatic glands. The first or primary infection is very disastrous to the animal unless the number of germs injected is very small and their disease-producing power is very weak. Where animals are immunized—that is, tubercularized—for further experiments a very weak culture or strain of tubercle bacilli is used, and only a very small number are injected. Later a very much larger dose may be injected, but until protected by previous injections or infections the resisting power of the animal to tubercle bacilli is very feeble.

To sum up, we may say that the first reaction of the body cells to tubercle bacilli differs from later infections. The first response is similar to that against any foreign protein substance. There is reason to believe, however, that there is some latent reaction against the tubercle bacillus, for it has been noted that races civilized the longest are more resisting to tuberculosis. The disease in the members of these races is more chronic and less fatal. But in all

animals there gradually arises by infection with tubercle bacilli an increasing amount of resistance or immunity. With every new infection there is developed an added amount of resistance. Finally and by the time adult age is reached (some authorities believe at the age of 7 to 10) resistance to the tubercle bacillus is so great that it is difficult to see how a sufficient number of germs could be received from the outside to cause disease provided one is reasonably sanitary in his habits. In other words, when an adult develops tuberculosis in later years, it is from the breaking down of a tuberculous focus in his own body and not from germs that he has received from the outside. He has infected himself.

PREVENTION OF TUBERCULOSIS.

We can not say exactly how tubercle bacilli are passed from one host to another. At one time it was believed that the bacilli were carried by dust; that the tuberculous individual spat tubercle bacilli on the ground: that these bacilli became dry and were wafted through the air to the nearest victim. Later on it was believed that tubercle bacilli were carried in the spray caused by coughing. The fact is, we do not know. It is most probable that infection comes to the child by getting in direct contact with sputum. There is also a possibility that milk from tuberculous cattle may be a cause. For this reason great care should be used in guarding the milk supply of a city or town. We do not know whether the tubercle bacilli reach the lungs by way of the tonsils, stomach, and intestines, or by being inhaled. Why in one case immunity is established and in another tuberculous disease results depends principally on the number of tubercle baccili received. If the first inoculation or infection contains only a few germs, the body cells are able to localize the germs and later infections develop a high degree of resistance. On the other hand, if a large number are received the infection is not localized: it becomes deep seated and at some time later may break down and cause tuberculosis as a disease. There will always be a certain number of border-line cases who have received a sufficient number of germs so that they may or may not develop tuberculosis as a disease, depending on their condition of life. For the last 100 years there has been a gradual decrease in the number of deaths from pulmonary tuberculosis. During the same period the standards of life have risen; it has become easier to earn a livelihood; the hours of labor have been shortened; better houses have been erected to live in: life has become more worth while. These factors have helped the border-line cases to keep up their resistance and kept the tubercle bacilli from gaining the upper hand. Anything that interferes with the health of a nation increases the amount of tuberculosis. In England it has been noted that with an increase in the price of bread there has been an increase in the death rate from tuberculosis.

CHILDHOOD INFECTION.

We may consider, then, that the tubercle bacillus is to be found among all civilized people. According to our present knowledge one is at a loss to conceive how infection may be prevented. Hope lies rather in the prevention, not of infection, but of massive doses of

infection. The child is able to ward off small infections, but until a growing child has developed a resistance to the tubercle bacillus that is relatively protective, until he has left off testing his knowledge of his enlarging world through the sense of taste and has been taught habits of personal hygiene, he must be kept away from coughing tuberculous cases, where he is sure to receive, not a few, but millions upon millions of tubercle bacilli. Everyone should know that it is next to criminal to allow children up to several years of age to live with parents, guardians, or attendants who are coughing and spitting up tubercle bacilli. If we can keep the child from being grossly infected we will reduce tuberculosis to the minimum, and to this end all sputum containing tubercle bacilli should be destroyed.

Proper disposal of sputum is taught in the sanatorium. The essential thing in the disposal of sputum is that the sputum be not discharged broadcast but be retained in something, such as a sputum cup, until it can be destroyed. The spitting habit should be discouraged, not only because it is a spreader of tuberculosis but of respiratory diseases in general. The use of the paper napkin folded twice on itself is perhaps the most esthetic manner. The napkin covers the face when the patient coughs and receives the sputum raised. Burning is the most satisfactory way for its ultimate destruction. Where the sputum cup is used any good disinfectant, such as formalin (which is 40 per cent solution of formaldehyde gas in water), used in the strength of 2 to 3 per cent and carbolic acid in 5 per cent strength is satisfactory. Steam disinfection, or boiling, is preferable to the use of disinfectants. It comes next after burning in efficiency.

FEAR OF TUBERCULOSIS.

We have learned that tuberculosis is acquired in childhood; that when the adult develops tuberculosis in later life it is from a tuberculous area, breaking down and spreading within his own body. Most tuberculous authorities believe that there is no danger in working with arrested tuberculous cases; that the danger is practically nil, even though they are an open case. It is known that nurses in tuberculous sanatoria rarely break down with the disease, and where they do there is often evidence at hand to show that they have had the disease prior to entering the service in the sanatorium. It is seldom that both husband and wife have tuberculosis, either at the same time or later. The children become infected but not the father or the mother. Cases have been reported of one wife burying two or more tuberculous husbands without developing the disease.

Colonel Bushnell quotes Pollak, of Vienna, as follows:

> Children over 4 years of age do not appear to be unfavorably affected in any way by the entrance of a tuberculous individual into the family circle, while those of lesser years grow up more delicate than their older brothers and sisters.

Colonel Bushnell quotes Bergmann as follows:

> [He] had a very similar result in Sweden. He found that with children of tuberculous families the mortality from tuberculosis reached 12 per cent in those exposed during the first years of life, and 11.8 per cent of those ex-

posed during the first four years. But no children exposed after the fourth year have died of tuberculosis, and no cases of tuberculosis have developed from exposure after the seventh year.

Practically all the evidence at hand indicates that adults do not develop tuberculosis as a disease because of contact with tuberculous adults, but that when they do develop tuberculosis as a disease in later life, it is because of infection received in childhood. The tubercle bacilli were walled off, they were buried away in a deep Rip Van Winkle sleep, and though walled off they were ready when the resistance of the individual became weakened by disease, lack of food, or overwork to break out of their prison and cause disease.

NATURE OF TUBERCULOSIS.

One must think of tuberculosis as developing very gradually. He must realize that the disease ebbs and flows; that the battle favors now the host, now the uninvited guest. That the disease may last for years; 10, 20, or even 40 years. That of all the chronic diseases tuberculosis reacts as favorably as any to treatment. But tuberculosis does not begin as consumption. Consumption is the end; not the beginning. In the beginning the disease is mild. It may never be recognized. Tuberculosis may be arrested without the person's knowledge that he had the disease, although he may have realized that he was temporarily below par. Some cases recover with little effort. Others after a long struggle. Tuberculosis may be arrested anywhere from the beginning to near the end, but the battle is more severe, and harder to arrest toward the latter end of the disease. In the beginning the outcome is more hopeful. The majority of cases can be arrested if they are willing to play the game according to the sanatorium method. Periods of arrestment and activity may follow one another at regular intervals. Repeated breakdown may be repaired, but every break means more destruction of lung tissue and a longer period for recovery.

The battle grounds—The tuberculosis lesion.—It is difficult to get a clear idea of what goes on in the area where tubercle bacilli are growing and multiplying. It is a struggle between the bacilli on the one hand and the body cells on the other. It is not a simple process; it is complicated like a military conflict. Tubercle bacilli by their ferments seek to get food, and the body cells by their ferment seek to digest and break up tubercle bacilli and stimulate the production of cells that localize and wall off tubercle bacilli. Where the resistance to the germs is well developed and the tubercle bacilli are few in number, there may be a destruction of the germs with but little evidence remaining that there has been a struggle. Where the bacilli are present in larger numbers, they are able to fight better, and the body cells react by localizing and walling them off by scar tissue, or as it is usually called, fibrosis. Where the bacilli are present in still larger numbers the resistance is still less favorably developed. The tubercle consists of a piling up of cells surrounding a clump or mass of tubercle bacilli. Where several of these tubercles unite the center part becomes separated from the blood supply and there is a tendency for it to degenerate and become dead tissue. A limited amount can be taken care of by the usual processes of repair, but where the mass has become too large the only way than nature can

secure a healing is by allowing the mass of dead cells or tissues to separate and be cast off through the formation of a cavity. The same condition is noted in the common boils or abcesses that one has on his body surface. Cavity formation is common in pulmonary tuberculosis. Every case that is spitting up germs must have a smaller or a larger cavity connected with one of the bronchi. Small cavities may heal; the larger cavities are, the harder it is to secure healing, and above a certain size, depending upon conditions, cavities can not heal. Cavities in time become well walled off, and the amount of scar tissue surrounding them may be enormous. It is believed that it takes from three to four years for the development of the maximum amount of scar tissues.

TREATMENT OF PULMONARY TUBERCULOSIS.

Colonel Bushnell says that " in tuberculosis we prescribe not medicine but a mode of life." He says that pulmonary tuberculosis as it is usually seen manifests a tendency to heal, or at least a tendency to become localized, so that many years may pass by before the disease gets the upper hand. This indicates, he says, an immunity, and usually an immunity or resistance of high degree. Colonel Bushnell teaches that the treatment of pulmonary tuberculosis should not be directed toward the destruction of the tubercle bacillus, but to restore the patient to his previous immunity. Drugs are of but little use; they may be of decided harm. We depend for recovery on the building up of the person's general health. It is a matter of reducing the outgo of energy to the income. Financially one can not spend more than he makes without going into debt. If a man spends $150 a month and makes only $100, he will soon be a bankrupt. Physically it is the same thing. Where the digestion is poor, the blood poisoned, and the body cells weak, they can not produce—that is, release—as much energy. It is necessary that a person conserve his physical energy and reduce his outgo of energy to below his income. The essentials in the treatment are usually given as rest, food, fresh air, and medical supervision in a sanatorium.

Doctor Trudeau, of Saranac Lake, N. Y., established sanatorium treatment in America. He proved that the ideal place to take treatment for tuberculosis is in a sanatorium. The essentials can be secured elsewhere but against the greatest odds. The sanatorium is a health school. The patient goes to the sanatorium to learn, as Colonel Bushnell says, a new mode of life. He goes to the sanatorium for knowledge that will aid him to get well and that will enable him to learn how to live so that he may stay well after he has recovered. The sanatorium is necessary because of the instincts of the crowd. People seek to do as other people do. It is easy to rest in the sanatorium, because everybody else is resting. It is difficult to rest at home, because at home everybody is working. In the beginning it is difficult for the patient to rest. He must be taught to relax, to put away worry, to get over his homesickness, and to suppress other depressing emotions. In time the patient is able to spend his days in " a kind of busy idleness which makes them seem not long." The three essentials: Rest, food, and fresh air. The treatment in the sanatorium consists of (1) rest and exercise adjusted

to the patient; (2) good, nourishing food; (3) fresh air and the daily program. This latter means careful supervision. Every patient must have his case adjusted to the program and the amount of rest and exercise that he can take must be carefully and definitely prescribed in writing at least once a week. As Colonel Bushnell says, to expect the best results one must have a good physician; he must have faith in that physician, and he must be willing to cooperate.

Food is one of the essentials. We do not believe now as formerly that one should eat an excessive amount of food. Usually it is not necessary to eat between meals and after one leaves the sanatorium he should choose a general well-balanced diet and should eat enough to keep up a constant weight. Regularity in eating is essential (see the digestive system).

Fresh air is an important element in the treatment, but it is not as important as rest. It is advisable for one after leaving the sanatorium to sleep in the open air, or at least in a room where there is freely flowing air, as in a corner room, with the head of the bed placed between the windows. Air in motion is fresh air. It is not absolutely necessary to sleep in the open air, but if one has an inside job he should make a special effort to do so. It will well pay him to build a sleeping porch.

Climate.—Before the discovery of the tubercle bacillus it was the general medical opinion that tuberculosis was not infectious; that it was caused by taking cold, exposure to the weather, sudden chilling as by drafts, climatic conditions, etc. It naturally followed that climate was a big factor; that it was an essential in the cure; hence a mere change of climate became the common method of treating pulmonary tuberculosis. There is no question that a favorable atmosphere has healing qualities. A good climate is a helpful factor, especially in a chronic disease like pulmonary tuberculosis, where one is seeking to build up his general health. But the curative value of climate in tuberculosis has been greatly overrated. Climate is of value, but it can not replace the sanatorium, rest, food, and fresh air. Patients are recovering from tuberculosis in all parts of the United States where they are faithfully taking the cure in a sanatorium. Besides this it is difficult to find an ideal climate. There is no climate that is ideal the year round. Often the climate advised is not better for the person than the one he has at home.

The factors to be considered are temperature, humidity, and prevailing winds. Moderate changes in temperature are desirable. Cool nights with temperate days and an abundance of sunshine make it easy to take the cure. The outdoors is inviting. A high relative humidity is bad in summer and winter. In summer the humidity decreases the dissipation of heat because the evaporation of perspiration is lessened; the days are "sticky." Contrariwise, in winter humidity causes a more rapid loss of heat through conduction and radiation. Cold, damp air is chilling; it is cutting and biting. In hot weather winds are often desirable and refreshing, but if strong they may bring clouds of dust. Dust and smoke, if present in more than small quantities, are very objectionable. The cold of winter is increased by winds. Cold, quiet air in winter is usually exhilarating. It has been noted that the improvement of sanatorium cases for the most part is greater in the late fall and winter months.

Before a change of climate is made, a careful study should be made and every factor considered. The advantages and disadvantages should be weighed one against the other. Will separation from home and friends result in homesickness and loneliness? Will the essentials in the cure be provided? It costs more money to travel and live in a new climate. Is the patient able to travel? For years almost dying consumptives were advised to seek the magic influences of a far-distant climate in the quest for health. They sought in vain, like seekers of the fabled pot of gold at the foot of the rainbow. It is a serious thing to advise a tuberculous man to change climates. It is better to refer him to a physician qualified to render a common-sense judgment after a due consideration of the conditions, the advantages versus the disadvantages.

Chapter X.

PHYSICAL AND INDUSTRIAL CONVALESCENCE.

When one speaks of an active tuberculous case, or of activity, he has in mind a patient who is being overpowered by an absorption of poison from the tuberculous area in his body. One must bear in mind that symptoms which are the result of poison and symptoms that may result from the after effects, or as we may say, symptoms during convalescence, may be confused. It is difficult to draw a sharp line between symptoms caused by the absorption of poison and symptoms resulting in convalescence, which are the signs of a damaged physical machine. The only practical means of separating them is by the use of the clinical thermometer. Fever indicates active disease. Fever in tuberculosis may be defined as a body temperature of over 99.2° F., or 37.3° C., at any time during the 24 hours. Where there is a variation between morning and evening temperature of over 2° one is justified in assuming that fever is present. It is not believed that patients pass from active to inactive disease in one or two days. Usually the period covers an indefinite time. It may be likened to the pendulum of a clock gradually running down. In most cases some days indicate an absorption of poison, while on other days the patient seems to escape. At last he starts on his convalescence. Patient must be cautioned against trying to decide this point—that is, when convalescence begins. He should rely on the judgment of his physician. It is always better to continue the complete or nearly complete rest during the period of doubt. Safety first.

TREATMENT OUTLINED.

The treatment of pulmonary tuberculous cases and their restoration to health and complete physical and industrial convalescence logically falls under three periods: (1) The period of active disease (rest in a sanatorium); (2) period of physical convalescence (graduated exercise in a sanatorium); (3) the period of industrial convalescence (training in special centers and general training with limited medical and nursing supervision).

We have considered the treatment of the tuberculous case up to the point where convalescence begins. It is difficult to decide just when the patient passes from an active to an inactive stage of the disease. It is the writer's practice, however, to start graduated activity a few days after the patient's temperature does not rise above 99° F., or 37.2° C., at any period during the 24 hours. Beginning with 5 minutes a day, the first exercise prescribed consists of acts concerned with the daily hygiene, as shaving, cleaning the teeth, washing the face and hands, etc. Later, going to one or two meals in a near-by dining room. Along with the daily hygiene, light occupational work, as beadwork and batik (making of shawls, scarfs,

etc). But with increasing strength, and as soon as possible, this sort of exercise should give way to some constructive work; something that will better fit the patient for his old occupation or for a new vocation where a change is necessary.

The two adjustments.—On entering the sanatorium with symptoms of active disease, the patient finds it necessary that he adjust himself to a life of ease. He must learn how to pass his working hours in a dreamy state of idleness. This first adjustment is difficult to accomplish; it is acquired by painstaking efforts on the part of the physician and the patient. It is the duty of the physician to teach the patient how to rest, and the reasons why he must reduce his physical outgo to less than his income, and that in complete bodily and mental rest lies his hope for recovery. After months of sanatorium treatment the patient becomes adjusted to this idle life. Where he once found it irksome he now finds it easy to beguile his time in harmless recreation. He has replaced his habits of industry by habits of idleness. He has acquired a taste for leisure and for the recreation that leisure provides. Unconsciously the nomadic instincts of roaming idleness, suppressed by generations of civilized industry, are established.

But with loss of fever and other signs of tuberculous toxemia, another adjustment becomes necessary, the habits of idleness must be replaced by habits of work. The purpose of graduate exercise in the treatment of pulmonary tuberculosis has not always been held clearly in mind. Its function is dual. The increasing activity under medical prescription stabalizes the health of the individual during physical convalescence, but its purpose is more than mere restitution of health. It must readjust the man to his previous industrial habits.

GRADUATED EXERCISE.

It is important that early in his physical convalescence and in the beginning of his graduated exercise that a distinction be made between the exercise prescribed for recreation and that for productive effort. One must be impressed that with his returning strength and power he should be retrained in habits of industry; and that during his physical and industrial convalescence his activity should be proportioned equitably between work and play.

Prescribing of graduated exercise.—Physical convalescence is a long and weary period without some worthwhile activity, such as vocational training. It changes one's views and stimulates his morale when he sees that he is not wasting his time, that he is getting somewhere, and that when he recovers he will be able to carry on at a job where he can earn enough money to make his life worth while. This desirable end, however, is reached by traveling along the straight and narrow way. One is reminded of Christian in Bunyon's Pilgrim's Progress. You will recall the difficulty that Christian had on the road from the City of Destruction ere he reached the Celestial City. So it is with the convalescing tuberculous case. He encounters many difficulties. He meets many pitfalls by the way. The most treacherous and dangerous of all is that of overdoing—the taking of too much exercise or activity. For the tuberculous person

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activity or exercise should be thought of as medicine. Graduated exercise is a very powerful remedy. It calls for the same skill and knowledge that is necessary in the prescribing of any poisonous medicine. It is necessary for the convalescing tuberculous case to realize that only the careless and ignorant take powerful and dangerous medicines without securing the advice and a prescription from their physician.

It is just as foolhardy for the tuberculous case to take graduated exercise on his own knowledge and information as it would be for him to take morphine or strychnine without a prescription. He does not possess sufficient knowledge of physiology to treat his own case properly. His wishes, desires, and fancies must not determine his daily activity. In the sanatorium the graduated exercise should be prescribed in a prescription. In a well-managed sanatorium the physician carefully writes out the kind and amount of exercise that he believes the patient is able to take. This activity he increases or decreases as the condition of the patient changes. The prescribing of graduated exercise calls for system; the patients must be prescribed for individually, and certain definite records must be kept. It is the practice of the writer to teach his patients in the ambulatory stage to take their own pulse and temperature and keep a record of their symptoms on a chart. This chart contains space for the prescription by the physician so that the prescription and the daily records may go together. During the early convalescence of the patient the records are reviewed and the exercise prescribed every other day. If unfavorable symptoms develop the patient is immediately put back on full rest. Later the interval is increased, but at least once a week the chart should be reviewed and the patient's exercise increased or decreased as the patient improves or goes backward. The task is a difficult one. There must be full cooperation on the part of the patient with the physician. The physician must be willing to devote infinite patience and attention to the smallest detail. He must direct and inspire enthusiasm. The patient must have faith in his physician. He must do his full share by religiously taking the cure.

In short, the prescribing of graduated exercise is not only a science, it is an art as well. It is a science in that there are definite laws and rules that govern; an art, in that one is not only treating a physical machine damaged by disease, but also an individual. The science calls for a thorough knowledge of tuberculosis and its effect on the human machine, but the art is not learned through textbooks but by experience. It is acquired through the school of adversity and of hard knocks where failure and disappointments are writ large.

The physiology of graduated exercise.—One should think of graduated exercise as a gradual reduction of the absolute rest that was needed during the active disease. When the patient is prescribed 2 hours of graduated exercise it means that he is prescribed 22 hours of rest in bed or in the "curing chairs," as well as 2 hours of physical and mental activity. Ideally graduated exercise covers all the activity—useful work and recreation—that the patient takes. The graduated exercise program should provide for and prescribe (1) the productive work, such as training, etc.; (2) the time necessary for

personal hygiene, such as eating, shaving, cleaning of teeth, etc.; (3) the kind and amount of recreation. It is very essential that all the activities of the man be considered and prescribed for. It is easy to overdo—to take too much activity. It must be emphasized that rest is as important as it was in the early part of the treatment. The difference is less rest is needed because the income of physical energy is greater and there is less need for reducing the outgo. The prescribed activity may apparently result in harm, not because it is too much in itself, but because added to the activity that the patient takes on his own account the total is too great. In short, the term graduated exercise should be thought of as graduated rest and exercise and activity should not be taken unless it is specifically prescribed.

PHYSICAL TRAINING.

Graduated exercise and physical training have much in common. Both are based and should be prescribed on the same general principles. Physical training dates back hundreds of years. It started with the development of games. The Mikados in Japan encouraged the art of wrestling 25 years before Christ. The Olympian games were established in Greece several hundred years before the Christian era. Cyrus, King of Persia, forbade the eating of a meal until one was fatigued with some labor.

The necessity for physical training arose with the division of labor. Since men began to specialize, some doing mental work without any physical activity, it has become necessary to provide enough physical activity to keep the human motor in efficient working order. It has been determined that the average healthy laboring man can do without injury from 900 to 1,000 foot-tons of work. One foot-ton of work equals the amount of energy necessary to lift 1 ton 1 foot high or 1 pound 2,000 feet high. It has been estimated that to keep the three great systems of supply and disposal—the digestive, respiratory, and circulatory as well as the muscular system—efficient, it is necessary that the human motor do at least one-sixth of this amount of work, or about 150 foot-tons. For the arrested case this may be relatively too much, but a certain amount of work is advantageous. Recovery is hastened by use, for the body cells have a tendency to atrophy, to become weak and sickly, if they are not given a judicious amount of work to do. It is, of course, very necessary for the tuberculous to stay within his limits of safety, but this may be accomplished quite readily by carrying out graduated exercise faithfully and systematically; that is, by never taking more activity than is prescribed by the physician. On the other hand, unless excused by the physician, all the exercise prescribed should be taken.

To sum up, during the active part of the disease the tuberculous individual was unable to take any physical exercise. He was compelled to do this because his limited income of energy made it necessary to guard his outgo. In other words, during the active disease he was forbidden to take exercise. Not because his cells did not need exercise, but because his system could not afford to spend the energy that the exercise would require. With the advent of convalescence and with the necessity gone for complete rest, it is important that

the muscle cells should be exercised and that they be brought back to their normal condition; for moderate activity increases the general condition of the body and hastens the consolidation of scar tissues surrounding the tuberculous areas in the lungs. But this must be done according to the laws of physiology. It is not necessary, however, to emphasize the need for bodily activity. The point to make is that physical outgo must be held safely within the income during convalescence.

The general principles of physical training.—Graduated exercise rests on the same general principles as does physical training. Physical training is best accomplished by increasing the muscular activity by gradual degrees as to effort, pace, and rest periods in accordance with the general condition of the human motor. The object of physical training is to exercise physiologically all the body cells, with the purpose of developing them to their highest efficiency.

Regulation of muscular force.—Nature economizes. She regulates muscle force to the resistance that must be overcome. In physical training it is important to see that this resistance that muscle force must overcome is (1) constant, (2) continuous, (3) submaximum, and (4) graduated. The resistance must be constant. There must be no sudden variations or jerks, etc., that are liable to injure nerve and muscle cells. Secondly, the resistance must be continuous. This does not mean, however, that there should not be intervals of rest or repose, but it does mean that the muscles must become used to exerting their power continuously. Thirdly, it is very important that the resistance be submaximum; that is, less than the muscles are able to overcome. This limitation of resistance is very essential. It is more vital in graduated exercise than it is in physical training because while in physical training an overload may result in a temporary reduction of capacity, in the convalescent tuberculous case it may result in a lapse of immunity as well.

Functional hegemony.—In the prescribing of physical training one should bear in mind the law of functional hegemony. In accordance with this law the active working cells are supplied with increased amounts of blood and it is important that muscle activity and digestive activity should not be going on at the same time—another kind of overloading. This means that one should not prescribe physical training or graduated exercise within at least a half hour of meals which are composed largely of carbohydrate and longer where the meal is more protein. Physical training where it is carried out satisfactorily results not only in an increase in size of the muscle cells, but also a functional increase in the great systems of digestion, respiration, and circulation.

Benefit of prescribing useful work.—The nature of the resistance that one must overcome in physical training is not as important as the factors above considered. In graduated exercise, however, it has been found advantageous to prescribe work that accomplishes something. Useful work, like the old adage, kills two birds with one stone. It adds to its value if one can see that he has accomplished something by his work. In training the individual can not always make something, but even in monotonous work—for example, training for motor control, as typewriting, piano playing, etc.—he is stimulated by seeing gradual improvement, in ability to do as well as in health.

Dependence of systems on each other.—We have been considering so far physical training from the standpoint of the muscle cells and personality of the worker, and only incidentally its relation to the circulatory, digestive and respiratory systems. It is, however, quite necessary that these systems be considered and that physical training be adjusted to their varying capacities. The different parts of the body are in very close and intimate connection. As soon as the muscle cells become active the news is carried to the heart and lungs: at once they respond by increasing their rate and production. Their production is accurately and delicately adjusted to the muscle cells; just the supply of oxygen that is needed by the muscle cells is furnished them, but there is a limit to the supply of oxygen and disposal of CO_2 that the circulation and respiration can accomplish in any unit of time, as, for example, one minute. To demand more means overloading, and overloading means stalling of the human motor. When all the systems are considered—(1) neuromuscular, (2) respiratory, (3) circulatory, and (4) digestive—physical training as well as graduated exercise is placed upon a physiological basis.

Necessity for short rest periods.—The necessity for short periods of rest and repose has been made clear by our studies of fatigue and vital combustion in the cell. We recall that the body cells release energy in the form of heat and work by burning up food matters, but it is important to remember that this combustion can not go on until the energy containing matter has been built up into the cell substance. This burning (slow or vital combustion) as it is called, breaks down the energy containing matter in the cell faster than the cell is able to absorb it and build it up into its own substance. We may think of the energy that is stored up in the cell as reserves. As the cells during activity can not build up energy containing matter into their substances as fast as it is burned up, its reserves are gradually used up. Short rest periods are necessary for the cells to replace their exhausted reserves. One may think of the cells' reserves as money in the bank. When one has money in the bank he is able to spend more money than he makes, but he can spend more only while his bank account lasts. So with the cell.

In the study of fatigue it has been found that the rapid development of fatigue may be an indication that one or more of the systems are being overloaded. Fatigue may develop either rapidly or slowly. The several systems are nicely balanced to do the work required and while the circulatory and respiratory systems can supply increasing amounts of oxygen and energy containing foods and dispose of the waste CO_2, etc., muscular action may be so rapid and so strenuous that it calls for more than these systems are able to supply. The balance or synergy (co-operation) of the systems is broken and fatigue very promptly sets in. With an accurate knowledge of fatigue physical training can be regulated with skill and with little danger of doing harm but it requires care and attention and in the prescribing of graduated exercise to the convalescent tuberculous case the keeping of definite records. Even with proper records one must be conservative and it is the practice of the writer to allow a factor of safety 25 per cent in the prescribing of graduated activity. He never prescribes more than 75 per cent of what he believes the patient can do with safety. If the physician with a knowledge of tuberculosis and physiology recognizes his limitations and considers it necessary to

allow a factor of safety one can see the folly of a convalescent tuberculous case trying to prescribe for himself.

Trained to guard health.—In a chronic disease like pulmonary tuberculosis where the cooperation of the patient is essential, it is the belief of the writer that he should be told the condition of his lungs and that part of the burden for his getting well should be placed on his shoulders. It is the writer's practice to take the patient into his confidence. The patient is told fully and frankly his condition and what he must do to get well. In the Cook County Tuberculosis Hospital near Chicago the writer developed records which have for their purpose the training of the patient in the observation of his own symptoms. While taking graduated exercise the patient is trained to take his own pulse and temperature. He is taught to keep his own chart and records the symptoms that are useful to the physician in prescribing graduated activity. The patients are largely placed on their honor. A nurse checks up the temperature two or three times a week to be sure that the patients know how to take their temperature and are recording it properly and conscientiously. When one recalls that two or three years elapse between the beginning of convalescence and thorough healing and that during this time there is a possibility and at times a probability even of a breakdown, it is very easy to see that the man has a decided health hazard. There is a definite necessity for the man knowing how to guard his health hazard. When the man has left the sanatorium and is not under close medical supervision, Who better can be on guard than the man himself? If he must protect and guard his health should he not be trained to do so? It is of importance that he be trained for this task. It should be a habit with him. He should take his temperature and note his symptoms just as he eats and observes the weather. He should stand on guard fortified with a knowledge of tuberculosis hygiene. It is not sufficient that he know about tuberculosis and signs of activity, the so-called danger signals, he must have the habit of guarding his health. In no other way can he avoid a relapse, or, should relapse begin, discover it quickly and immediately start treatment to regain his lost immunity. Objections have been raised to this method of treatment; it has been the writer's experience, however, that where the physician is willing to do his duty and does not have too many patients that he can secure their co-operation and that they will report their temperature and symptoms accurately and conscientiously. If one will not play the game fair under supervision, he will not later. There is little to be gained by improvement in the "san" for *disaster is the* "*handwriting on the wall.*"

Danger signals, signs of a loss of immunity.—The most important symptoms indicating loss of immunity in tuberculosis are (1) a temperature of 99.2° F. and 37.3° C. or over, and a difference between morning and evening of over 2°; (2) increase in pulse rate; (3) an undue sense of fatigue; (4) loss of weight; (5) increased cough and sputum; (6) loss of appetite; and (7) night sweats. It should be recalled that during the early part of convalescence one normally has a tendency toward symptoms 2 and 3, but the tendency should grow less and less. It should be pointed out also that these symptoms are not alone characteristic of pulmonary tuberculosis, but that other

chronic diseases and illnesses like sinus diseases, chronic appendicitis, apical abscesses of the teeth (pus pockets), chronic malaria, hookworm, and some nervous disorders give similar symptoms. It is well, however, for the tuberculous case to be suspicious that these symptoms are due to tuberculosis. If they do not decrease with an increased amount of rest the patient should place himself under the care and observation of an experienced physician that the real cause may be determined and a remedy provided.

Chapter XI.

THE TUBERCULOUS AND HIS JOB.

CHOICE OF A VOCATION.

If one will eat, he must work. Work means a job, at least for the majority of mankind who are compelled to earn their living by their own mental and physical effort. If they don't work they starve. For as we have learned, everyone lives on the things that are produced by labor. How to best earn one's bread and butter is a serious problem. As an individual grows out of childhood it becomes necessary to choose his life work, his occupation or vocation, that the years of childhood and early youth may be spent in training, and preparation for life's work. The choice of a vocation is usually difficult. It calls for a most careful study on the part of the person, his parents, and those who are interested in him. It is a real problem. Its proper solution is vital, for one's whole life is in the balance. A wrong choice may not determine one's whole life, but it often does and the man continues to be a square peg in a round hole. Some few individuals are favored by Nature. They have definite aptitudes and qualifications which stand out prominently and determine their vocation. As, for example, where one has special musical or dramatic ability or special skill for drawing form and blending color there is no difficulty in choosing the right profession. But the average individual does not have any outstanding qualifications. His aptitudes are hidden. In his case it is a real problem. It can be solved only after the most careful study.

As an American living under a democratic form of government one likes to think that he may choose the vocation or occupation that he will follow, and so he may, but usually one's occupation or vocation is determined largely by circumstances and by his parents. It is only the unusual individual who is able to surmount difficulties and raise himself above his station in life. America abounds in opportunities, but the competition is growing keener and for one to succeed he must possess the necessary qualifications for his chosen work in order to make good.

The wrong vocation is usually chosen for the following reasons: (1) Lack of information about jobs, (2) lack of knowledge of one's physical and mental qualifications, and (3) desire for money and station in life. The amount of money that one can make on a job is often the deciding factor in the choice of vocation. It is not unusual for a physician to try to become a surgeon not because he is better fitted for surgery, but because there is more money for the same amount of work and ability in the practice of surgery. One should choose one's vocation on the basis of fitness and ability. He should have the physical and mental qualifications necessary for doing the job. This is particularly true in the case of the tuberculous because he has an increased physical handicap and there is

a positive danger of overloading. Lack of information causes him to choose his job by what is known as the law of trial and error. The individual takes up one job after another until he finds one that proves satisfactory. This method is wasteful. It is necessary because his knowledge of jobs is limited. It is the only way that he has for finding a job that is suitable. Ideally he should choose an occupation early, train for it, and follow it throughout his working life. Everyone gains experience in his work. This experience should be thought of as capital. As one grows in experience on the job he becomes more valuable; he can do that job better; separated from that job he is bankrupt.

How the tuberculous should choose a job.—It is somewhat more difficult to choose a suitable job for the tuberculous. In his case other factors must be considered but the general principles are the same. There has been a tendency on the part of some to desire lists of jobs that are suitable and those that are unsuitable for the tuberculous. It is not desirable, however, to have such lists for the choice of a job for the tuberculous is an individual problem. Each case should be considered as a separate problem and to put certain jobs on the blacklist may operate to prevent the proper solution in an individual case. It should be borne in mind that every industry has several operations in the manufacture of its productions. For example, it is said that in the boot and shoe industry there are 190 operations: in the printing trade 50, and in the making of light cloths, shirts, and overalls 52, and while usually all the operations are not satisfactory for the tuberculous there are usually some suitable operations in every industry. In short, there are but few industries that do not have some operations or jobs that are suitable for the tuberculous.

Capitalizing old jobs.—It is a basic principle that the tuberculous should not change their occupation or vocation unless there is a real necessity, as for example, severe physical work, excessive dust or poisons. Experience gained on a job is capital. Every effort should be made to prevent the loss of this capital and where a change is necessary every effort should be made to see if the man may not be trained for a similar vocation where he may capitalize in part at least the experience that he has acquired on his old job, for example, a plumber or a steam fitter may not have the necessary physical energy to do the heavy work required at his trade but he may have sufficient physical energy to carry on as a foreman or boss plumber or steam fitter. A course in blueprint reading and cost estimation may be all that is necessary to prepare him for the foreman position or even to establish him as a contractor, provided the necessary capital can be raised.

[Bulletin 59, Federal Board for Vocational Education.]

THE IDEAL JOB FOR THE TUBERCULOUS.

The ideal job for the tuberculous should consist of the following characteristics: In the first place, the job must not demand heavy physical labor; it must not require extreme nervous or physical tension. The man must be well trained and fitted for the position, not poorly qualified for the job. The essential factor is that the amount of physical energy and fatigue poisons that the body must produce in order to fulfill the labor requirements of the position are less than the man is able to produce without chronic fatigue.

If one were to give a total of 100 points for an ideal job, at least 60 should be proportioned to the amount of physical labor required—the less the amount of labor the greater the number of points. For example, one could give from 50 to 55 for a position like a bookkeeper sitting at a desk, perhaps the full 60 points to a bank president. One can not give to the average agricultural position, with long hours and laborious work, more than 30 points; with specialized agriculture, as, for instance, bee culture, more, perhaps 40 to 50, as the work is light.

Second. The question of health hazards on the jobs must be considered. A total of 20 points should be allowed. The presence of poisonous gases and materials; the degree of relative humidity, as extremes of moisture or dryness; rapid changes, as from hot to cold; intense heat or cold are adverse factors and would reduce the number of possible points. Fresh air is important. Other things being equal, fresh air is very desirable, but it is not necessary to have 100 per cent fresh air. A properly ventilated room, with sufficient light and freedom from dust and poisonous fumes, etc., is all that is necessary. Unfortunately, the question of fresh air has been unduly emphasized. It has been considered oftentimes, apparently, as the most important factor, whereas, as a matter of fact, it is quite secondary.

Third. The question of remuneration or wage is just as important as the question of health hazard for the job, for on it depends the providing of sufficient food and sanitary conditions to safeguard the health hazards at home. An adequate wage is an essential for the arrested tuberculous case. It enables him to secure the proper standard of living. He is at work 48 hours or less per week, and the balance of the time, 120 hours or more, he can definitely control and secure proper sanitary surroundings if he receives adequate compensation. It is just as important that he have a sanitary dwelling, with modern conveniences and surroundings, as it is that his place of work be so. It takes adequate wages to provide these comforts. A total of 20 points should be allowed for the factor of compensation. At least an average wage of $200 per month is necessary for the largest number of possible points.

PROJECT No. 13.

Problem: Are inside or outside jobs more ideal?

Directions: Choose 10 different kinds of jobs and rate using the above plan, after having studied health hazards, and place in a list the best first and the poorer last.

Question: Where are the outside jobs at foot or top of list?

HEALTH HAZARD OR DANGERS.

It is hard to find an ideal vocation—a job where there are no bad features. In some jobs one is in danger of losing one's life; in others one is threatened with dangerous tools and machinery which may cut off a finger, an arm or put out an eye. Or again one may work with poisons or in an atmosphere containing poisonous gasses or dust that injure one's health. In some jobs the danger to life or to health is small; in other jobs it may be very great.

It is quite necessary for the tuberculous to know the hazards and to choose a vocation where the dangers to health (health hazard) are reduced to the minimum. It is really impossible, however, to find a job where there are not some items or features that are injurious to health. It is necessary therefore that, (1) one learn the various items of danger to health that one meets on jobs and (2) know their importance, that is their relative value, for some of them may be serious while others may be neglected provided there are other items that compensate. It is easy to overlook serious items. Tuberculous persons have been known to change from one job to another on account of items that really were not bad and found after changing

that the new job was worse; that is more hazardous than the old one. The health hazard may be considered under the following angles: (1) Place of work, (*a*) physical items, (*b*) sensory and physical items, (2) nature and kind of work, that is the amount of physical and mental effort with the amount of fatigue developed.

Place of work.—The place of work is a very important factor. It may be indoors or outdoors; in a place that is dusty, that is damp, that is dry, or in a place that is excessively cold or warm. For the tuberculous the indoor job is usually less injurious to health than an outdoor job, because in the outdoor job there is more exposure to wind and rain, snow and cold in the winter and excessive heat in the summer. Temperature and the amount of water vapor in the atmosphere are very important. Where there is but little water vapor in the air it is spoken of as dryness and where there is too much, as dampness, as we have learned. The amount of water vapor in the air is told by the wet bulb thermometer. It is read off in terms of relative humidity, for the amount of water vapor that can be dissolved in the air at 40° which would cause dampness, at 85° would cause dryness. The use of the wet bulb thermometer should be encouraged. It is just as necessary to know the degree of dryness or dampness (relative humidity), as it is to know the temperature. In modern homes there is a decided tendency in the winter for them to become too dry, because the air on being heated becomes dryer and dryer and means must be taken to add sufficient water to the air to prevent this dryness. The wet-bulb thermometer decides the question "How much water must be added?" For the amount of water vapor that can be dissolved in the air is increased by heat.

Amar has found that the best temperature for a workshop is from 13° to 14° C. (55.4° to 57.2° F.); for offices and living rooms, 17° to 18° C. (62.4° to 64.4° F.) and for persons whose work keeps them sitting, a temperature not below 62.4° F. Americans, however, are accustomed to temperatures a little higher than this. For them 65° to 70° F. is more usual. Pulmonary ventilation is at a minimum with a temperature of 27° to 28° C. (80.6° to 82.4° F.), because at that temperature there is little or no loss of body heat and the amount of oxygen needed for heat production is reduced to the minimum. Above 28° C. (82.4° F.) with every increase in temperature the amount of work that one can do rapidly diminishes. Sudden changes in temperature as going from hot to cold or the reverse, working in ice plants, foundry, etc., are not desirable due to the shocks that they throw on the nervous system and the heat regulating centers. Dampness decreases the effect of perspiration (sweating) by hindering the evaporation of it and the removal of body heat. A crowded building is uncomfortable rather on account of the dampness and heat than on account of the CO_2 and other wastes in the air. In cold weather dampness increases the radiation of heat because damp air is a better conductor of heat. It carries heat away more readily than dry air. For that reason one speaks of a cold, damp wind as being "raw" and a hot, damp day as being "sticky."

Dust.—More than a small amount of dust is harmful, especially in tuberculous cases and those that have other chronic respiratory diseases, as chronic bronchitis, etc. Mineral dust is more harmful than dust from animal or plant products. Some kinds of mineral dust are more harmful than others, for example, dust from granite

and sandstone and other insoluble rocks is more harmful than dust from marble and limestone, for the dust particles from the latter are softer and more soluble and are more readily gotten rid of in the lungs. They do not prove to be as injurious as the granite dust, which is very sharp and insoluble. Fine dust is more injurious than dust which is composed of large particles which settle more readily. It is possible, however, for most dusty trades to be made practically dustless by the proper use of hoods and exhaust fans. Where the proper precautions are taken and the right apparatus installed one may go back to his old job, although dusty, with little fear of a breakdown, provided there is a minimum of physical work and the wages are good.

Sensory and psychic elements.—The physical aspects are not the only undesirable or injurious items of a job. (1) Excessive noises; (2) distractions of all kinds, unfriendly nagging and teasing workmen, grouchy and bluffing foremen, lack of system and order with no attention paid to scientific management; (3) fear of losing one's job are quite as important factors as the physical items of the job. These items are fatigue producing. It is necessary that the man be so thoroughly trained for a job that he will have no fear of making good or of holding his job. It should also be noted that the distance that he lives from his place of work should be considered, for it is tiresome to travel miles on street cars, and he may easily overdo—overload—simply by living too far away from his job. In reality he is working while going to and from his place of work.

The following table was prepared to list the common injurious or unfavorable items on one side and the favorable ones on the other side. The object is to show them in contrast.

UNFAVORABLE.	FAVORABLE.
Rain, snow	Fair weather.
Wind	Calm.
Dust	Very little dust.
Excessive heat or cold	Temperate.
Sudden changes	No changes or gradual ones.
Excessive dampness or dryness	Relative humidity 0% to 60%.
Poisons, copper, lead, zinc, acid, etc	Nonpoisonous materials.
Basements or underground	Above ground.
Bad ventilation	Good ventilation.
Poor lighting	Plenty of light.
Bad floors	Good floors.
Many distractions (See nervous leaks.)	Few distractions.
Lack of sanitary comforts	Sanitary comforts, recreation, quiet rooms.
Foreman grouchy	Foreman friendly.
Fellow workmen unfriendly, teasing	Fellow workmen cooperative.

THE KIND AND NATURE OF WORK; THE AMOUNT OF PHYSICAL AND MENTAL EFFORT EXPENDED AND FATIGUE DEVELOPED.

For the tuberculous the amount of physical and nervous energy expended on a job is important from a health hazard standpoint. As we have learned, there are three elements that must be considered in work and the development of fatigue: (1) Rate or pace, (2)

amount of effort, and (3) duration of the efforts. It is believed that these various items can be listed to advantage much as the items were under the place of work. This difference, however, should be made. The items in the undesirable column should not be thought of as necessarily bad (although they may be), but as undesirable in their relation to the items just opposite them. In other words, because an item is in the undesirable column does not blacklist it except relatively.

UNFAVORABLE.	FAVORABLE.
Quick movements.	Moderate economic pace.
Irregular resistance.	Regular.
Jerky movements.	Steady.
Peak loads (dull and rush periods).	Load uniform (during day).
9 hours or more.	8 hours or less.
48 hours or more per week.	44 hours or less per week.
7-day week.	5½-day week.
Sunday work.	Sunday for rest and recreation.
Standing.	Sitting.
Running.	Walking.
Carrying loads.	Free from loads.
Heavy tools.	Light tools.
Stooping and awkward positions.	Natural and easy positions.
Night.	Day.
Work part of year.	Work all year round, but with vacations.
Paid by day or week.	Paid by the piece (opportunity to regulate pace and rest periods).

This table emphasizes the difference between the favorable and the unfavorable items. These items have a relative value. In some places they may be less injurious, just as we have learned that the same amount of water vapor at one temperature may be dryness and at another temperature dampness.

A dollar is a dollar, but a dollar to a man who has only one dollar means more than it does to a man who has a hundred, for he may lose one dollar and still have ninety-nine, whereas, when "a one dollar man" loses his dollar it spells complete loss of capital. Relatively his dollar was worth more than the one-hundred dollar man's dollar was to him. Tuberculous persons have been known to give up one job for another because they did not understand the relative value of the various items that must be considered in their health hazard. Suppose for example, that one was offered two packages; that one of them contained a hundred dollar bill; that the other contained a twenty dollar bill. Would one take the twenty dollar bill because it was placed in a rich looking, beautiful case rather than the hundred dollar bill because it was placed in a poor, cheap, dirty looking box? There is no question which package one would take. Tuberculous individuals for years have taken outside jobs for no better reasons than one would turn down a hundred dollar bill and take a twenty, because it was in a better looking case. When one changes climate in tuberculosis it is usually like throwing away a hundred dollar bill and taking a twenty dollar bill instead because the twenty is handed out in a more attractive package. Pleasant and pleasing surroundings are advantageous just as pretty pictures on the wall in the dining room, but the charming pictures do not fill the stomach, supply vitamines, or furnish energy. In tuberculosis we must look for the substance rather than the form. One must not be

deluded. He should give up climate chasing, for it is like chasing the pot of gold at the foot of the rainbow.

Whether work is injurious or hazardous depends principally on (1) the amount of energy expended, and (2) the amounts of fatigue developed. We must recall that energy is released in the body cells, that muscular efforts require large amounts of energy, and that the tuberculous does not have the power to do this. His energy-producing functions are impaired. They must be conserved. Other things being equal the less physical energy he has to expend the better. Positions requiring stooping or assuming awkward or unusual attitudes are particularly bad on account of the extra amount of fatigue that is developed. Work that is irregular, that can not be done at an economic pace or requires excessive efforts, or is continued too long develops more fatigue and for that reason is injurious to the health of the worker. It should be recalled that jobs requiring rapid movements are more fatiguing than jobs requiring a slower pace and that they are more or less fatiguing, depending on whether the individual has a long or a short personal equation. Responsibility and amount of thinking or brain work that one has to do on a job adds to the amount of fatigue. Jobs requiring routine automatic action develop much less fatigue and are often sought after by individuals who wish to conserve their nervous energy for their recreation. In short it is necessary that the individual have the necessary physical and mental qualifications. He should be thoroughly trained for his job in order that he may avoid overloading, and reduce his fatigue to the minimum.

A SUGGESTED PLAN FOR PREPARING THE TUBERCULOUS CASES TO CHOOSE THEIR EMPLOYMENT OBJECTIVE.

Definite courses should be given to train tuberculous persons to choose their employment objective. This will not always be possible, but in the special schools for the rehabilitation of the tuberculous it should be accomplished. The necessity for it is evident. One should recall that to choose the right job requires a good judgment and a wide knowledge of vocations. A practical program should be adopted that will train the tuberculous for the choosing of their employment objective (vocation). It should consist of two courses and an inventory: (1) A course of job opportunities, (2) a course in hygiene and vocational efficiency for the tuberculous, and (3) an inventory of his capacity, physical and mental. The average individual knows but little about jobs and as little about his own qualifications, aptitudes, and physical condition. He should be given the facts so that he may properly solve his vocational problem. It can be accomplished by this program.

A course in job opportunities.—In the first place he should be given an opportunity to enlarge his vocational horizon. If one were lost in a forest his problem would be to find the shortest way back to civilization. To solve this problem, it would be necessary for him to locate the points of the compass, north, east, south, and west, and the direction to follow to reach the nearest point in civilization. By climbing a tree or some high elevation his horizon would be enlarged and it would perhaps include some object, as rising smoke or some other familiar thing that would indicate civilization and would

enable him to choose the right direction. So with the tuberculous case. His problem is to find a job he is suited for. A course in job opportunities will enlarge his vocational horizon. By a study of industry, commerce, and the different trades some job that is suitable is brought into view. This course should be made as efficient as possible. It should include laboratory work and actual try-out with tools and machinery, and where feasible, trips to different shops and factories where first-hand information can be obtained.

A course in hygiene and vocational efficiency.—It is not necessary to go into details and describe a course in hygiene and vocational efficiency for you have been studying such a course. When you have completed this handbook you should have a working knowledge of how the human motor operates and the precautions that you should take to safeguard it. To make it operate efficiently, you will need, however, besides this information a knowledge of your physical and mental capacity. This subject is considered in the following paragraphs.

An inventory of capacity.—It is very important that you have an inventory of your physical and mental capacity. You should know whether your lungs are well healed or whether they are barely quiescent and that months will pass by before healing is well established. You should know the amount of lung tissue destroyed and the resulting loss in pulmonary ventilation. Fortified by a knowledge of your lung condition and your limitations and a knowledge of hygiene you are prepared to stop short of the point beyond which you may not go with safety. In addition to this you will need an inventory of your neuro-muscular system, your personal equation, your mental aptitudes and qualifications. One needs to have his personal equation determined, for the job may be very fatiguing and unsuitable or the reverse, depending on one's personal equation. For, as we have learned, too rapid a pace increases out of proportion the amount of fatigue developed. Where one's personal equation is long it demands in his case relatively a slower speed or pace. It may be thought of as a kind of overloading. It is like the straw that broke the camel's back. It is possible by training to increase relatively one's personal equation, just as it is possible for a weak man to increase his muscular power by training.

EXAMINATIONS.

Examination of vision.—This inventory includes an examination of the several senses, especially those of sight and hearing. The eyes should be examined especially for defects of vision and sense (or perception) of color. It is important, for example, that a man who is taking training for railway work or to be a decorator, etc., should not be color blind, for these individuals are not able to tell red from green. In the case of a railway man, for example, such a defect may be very serious. It is necessary to test for defects in vision as it is not advisable to train for an occupation requiring close and accurate vision where there is defective sight unless these defects can be corrected by glasses. It has been found that defective vision increases very materially the amount of fatigue, causing headaches, etc.

Examination of hearing.—It is important also that the hearing should be examined. Persons who are deaf in one ear have difficulty

in locating the direction from which sounds come; they are more likely to be run over. Partially deaf persons often assume an unusual attitude and have difficulty in noting variations in machinery which are told by sound. They may speak in a loud tone of voice and suffer handicap in telephoning (because of a great increase in the amount of fatigue) and in positions where it is necessary to meet the public. A person may have a voice for singing, but he may be tone-deaf, a condition in hearing which corresponds to color-blindness in vision. It is evident that such a person would be wasting his time in trying to become a professional singer, or training for a vocation where tone is necessary. For example, the physician in the examination of the chest is greatly handicapped if he cannot tell pitch and is tone-deaf.

Mental examination.—And lastly, he should have an examination of his mental capacity by some of the standard tests as the Sanford revision of the Simon Binet scale for intelligence. The importance of a mental examination has not been sufficiently emphasized or understood, but to carry on successfully one should know his mental qualifications just as he should know his physical capacity so that he may not overload. One should recall that persons differ in their mental ability, just as they do in their physical ability, or as to size, color of eye, hair, etc., that some are gaints mentally just as some are giants physically. Just as some are stronger and more able to do hard physical work, so some have more mental ability and are able to do better and harder mental work. From a physiological point of view one should know his mental ability so he may avoid overloading. A few minutes spent on a mental test will determine more of a man's qualifications and his limitations than can be learned in any other way except by months of trial and error. One would not think of trying to train a common horse for the race track for it would be a waste of time. But it is not unusual for a man to want training for a job that he is really no more qualified to do than a deaf person is to become a telephone operator.

Chapter XII.

TRADE SCHOOLS: SCHOOLS FOR APPRENTICESHIP.

NEED AND PURPOSE.

The first trade school in France for training apprentices was founded in 1640. The importance and need for such schools will be emphasized by the following quotations from an address by M. Millerand, President of the French Republic, and from a book by Jules Amar on "The Physiology of Industrial Organization and the Reemployment of the Disabled."

"While it is true," says President Millerand, "that in a few weeks a laborer can learn to operate a machine, it is no less true, and profoundly true, that the interests of national production as of the producer himself, and the interests of the country, which has need for an educated and intelligent race, demands workers who are familiar with the whole of their calling, who possess scientific knowledge to understand the working of a machine; to repair it and, at need, to invent improvements."

Amar says:

For the organization of apprenticeship is a task which must be undertaken by and in a trade school, a natural prolongation of the elementary school. It receives the child under the conditions most favorable for teaching him a trade. By the age of 13 there will have been time to teach him the elements of his own language, mathematics, and the physical and natural sciences. This indispensable knowledge, however, can not have created in him a vocation of any kind. He is, however, fully prepared to receive a special course of instruction, a theoretical and practical training, devised with a view to his chosen trade. I would say that a theoretical training is necessary. It helps apprenticeship by explaining it. It sheds its light over all the details of work, revealing its defects and qualities without which progress would be slow and the finishing touches difficult or impossible. It develops a spirit of invention; a love of fine workmanship and a deep-seated love of the craft or profession. * * * for the trade school has a twofold superiority over the workshop; * * * I mean, of course, over the workshop alone. The trade school's scientific superiority is obvious. The workman, while he believes he is teaching the apprentice the whole of his craft [trade] is himself making no progress. From worker to worker, * * * not the smallest link of science is added to it. It is a vicious circle, * * *. The teachers on the contrary grow more learned from generation to generation. * * * Their pupils profit thereby. Modern industry demands this constant development of education be given the workers. * * * But the school must give this professional instruction, as a whole the advantage of theoretical education and environment are not alone sufficient. It must give the apprentice the practical training and instruction which is offered by the workshop itself.

The practice of a trade or craft is an art, but art is always an expression of a methodical, disciplined effort. * * * The arts and crafts are applied sciences whose eternal beauties in bygone ages enchanted the imagination to such a point that it erected them in Olympian divinities [Grecian gods]. *The worker who possesses an absolute grasp of his craft is the equal of the scholar* * * * The principles which should guide the practical apprenticeship are of physiological and mechanical order. * * * The teacher will carefully examine the aptitudes of his pupil; he will not leave him to mope at the lathe if he will only be happy while handling the plough; he will see that weakly subjects do not adopt callings requiring exertion. * * * The

apprentices will be taught what *hygienic precautions* they should take to safeguard their health, * * * and what accidents are to be guarded against * * *.

The education of movements is necessary in order (1) to render apprentices effective, (2) to increase their output, and (3) to diminish fatigue. The number and rapidity of these movements, and even the effort which they develop vary according to the individual and the nature of his work. * * *

[They are readily taught by] the movements of the model workmen highly skilled in their craft. * * * [or by] the graphic records of normal work. Disorderly and useless movements which give rise to premature fatigue will be reduced by means of the moving picture * * *. The conditions of apprenticeship must be adjusted in such a way as to gradually increase the output of its maximum limit while the workshop must be so organized as to reduce loss of time and the causes of fatigue to the minimum. But do not mistake me. The *object of an economy of time is not merely an increased production* * * *. It is intended to give the worker *habits of order*, and to confirm the idea that we should be as useful to others as to ourselves, if we avoided all aimless muscular efforts.

And lastly Amar takes up—

Mechanical considerations: From the mechanical point of view there is, as we have observed, a certain effort and a certain pace which are conducive to the largest output * * *. Tools should be adapted not only to the nature of the work but also to the age [and strength] of the worker, so that eventually an optimum equipment may be put together with which the workshop will provide the finished worker. At the close of his apprenticeship the young man ought to be practiced in the handling of this equipment; * * * his mind disciplined as well as his body, every detail of the practice of his craft, every form of mechanical agency, and every elementary operation * * * engraved in his memory * * *. If I were not afraid of discouraging good intentions I should subscribe to the verdict of the American scientist, Filbrethl: "The present system of apprenticeship is pitiable and criminal, considered from the apprentices' point of view; it is ridiculous from the modern point of view; and there are no words to describe its futility from the economic point of view."

These remarks apply because of the general lack of trade schools for apprentices.

In concluding these paragraphs on apprenticeship we will further quote from Amar:

The identity of the methods which should guide both physical education and the activity of the craftsman is obvious. It results from the geometrical and harmonious forms of the contractions of the muscles; it reveals itself indeed in the very effects of this contraction, since fatigue in the last analysis is always an intoxication.

Of the principles of the art of labor, I would lay especial stress upon order and the selection of movements. If, in order to execute any physical action whatever, (1) we make the strictly necessary movements, which alone are useful in executing it; (2) if we eliminate the useless movements, and regulate the succession of the useful, we shall effect a great saving both of time and fatigue. Our education, too, will profit greatly; a moral treasure will be added to the betterment of our well-being. The organization which I am speaking of involves the art of making movements appropriate to an end, and of making a rigorous selection of the same, tending to an economy of effort; in other words, of ordering them and utilizing them in the best possible manner.

Selection and *order* are, in truth, the characteristics of the new method, which will presently work an economic revolution to which no other can be compared. It is not purely mechanical; it does not turn a man into a soulless body, a blind and tireless force; [for] it embraces all the data of physiology and psychology.

Chapter XIII.

THE TUBERCULOUS AND HIS RECREATION.

In the last few years there has been a decided change in the trend of education. Teachers have come to realize that the school must train students for modern life. Prof. E. L. Thorndike, one of the greatest living educators, has outlined the new aims of education as follows: For the ultimate aims he gives (1) social efficiency, (a) civic, (b) domestic, (c) economic; (2) good will and (3) habits of harmless enjoyment. For the immediate aims he gives (1) health information, (2) habits, (3) ideals, and (4) interests. It develops from Professor Thorndike's teaching that the program of the modern school should consist of three divisions—(1) opportunities for study, (2) opportunities for learning how to work, and (3) opportunities for learning how to enjoy proper recreation. For hundreds of years the schools, colleges, and universities have furnished opportunities for study. It is only more recently that opportunities have been provided in schools for vocational training, and still more recently have opportunities been given for some training in recreation. With the increase in leisure that modern civilization affords the spending of that leisure in harmless enjoyment becomes more important and one may well say that it is just as necessary for one to receive training for recreation as it is for him to receive training for a vocation. In other words, the school should provide training that would teach one how to live; that is, how to spend with advantage and with efficiency the "24-hour day" of modern civilization.

A PHYSIOLOGICAL DIVISION OF THE DAY.

In poetry the day has been divided into three parts: (1) Eight hours for labor, (2) eight hours for recreation, and (3) eight hours for sleep. For the average person such a division is physiological, but such a division should not be applied to everyone, for some individuals need more rest and sleep, some individuals can do with less. It is important that each one learns the division of the day that is most physiological for him. For the tubuerculous it is quite necessary that he solves correctly this problem and that he makes this division a habit so that there is a regularity and a rhythm in his activity (work and recreation) and rest.

RELATION OF RECREATION TO WORK.

For the tuberculous proper habits of recreation are of the greatest importance. It is not infrequent that tuberculous individuals by changing their habits of recreation may retain their old jobs. It is necessary that they adjust their recreation to their work. They should choose their recreation so that it supplements their vocation.

If they are mental workers where their work calls for very little physical activity, they can with safety take more active recreation. Where their work calls for less than 150 foot-tons of energy and this amount is less than they can spend with safety, it is advisable to take some quiet outdoor recreation such as walking, playing croquet, etc. Where their work is more active it may be necessary for them to secure their recreation with the least amount of expenditure of energy. They may have to "cut out" all active recreation. It will help one to think of his human motor as being able to produce so much horse-power in 24 hours. If one uses 60 per cent of it at his work he has only 40 per cent left for recreation and for a reserve of safety. Ideally, the tuberculous should not have to use more than 50 per cent in his work. This will allow an expenditure of 25 per cent for his recreation and 25 per cent for a factor of safety.

HOW ONE SHOULD CHOOSE HIS RECREATION.

One should choose his recreation on the same general principles that he chooses his life work, for as we have learned recreation is activity. It differs from their work only in the fact that recreation carries with it an element of enjoyment, while work may or may not. A good workman, however, should enjoy his work. The ideal recreation for the tuberculous requires (1) that there be very little expenditure of physical energy, (2) that the activity in recreation and on the job leave a surplus, (3) that it observe the laws of fatigue. The ideal recreation for the tuberculous should require little expenditure of energy just as the ideal job. Here again the law of overloading must be considered. As one should not overload in his daily work so one should not overload in his daily recreation. Certain forms of recreation which are strenuous can not be taken at all, but there are many forms of recreation that can be taken in moderation and with benefit. One does not like to blacklist any form of recreation, but active exercises like lawn tennis, handball, football, baseball, etc., require large amounts of physical energy and can not be played without danger. Outdoor exercises like walking, croquet, golf, gardening, etc., are suitable except for special cases and are excellent for those who should take some exercise in the open air. There is, however, one form of recreation that must be put on the blacklist, and that is gambling. Gambling is bad from every point of view. It is too exciting. It is often played at night when one should be in bed resting, for it is not unusual for poker players to view the rising sun. It causes domestic disturbances. One usually loses. It is seldom that one makes any money except temporarily, and where one does make money he does not have an honorable vocation, for it is morally wrong to take money or value without giving value. It is not necessary to gamble. There are many other ways of getting recreation. It is a matter of forming good habits that will replace those of gambling.

FATIGUE IN RECREATION.

The laws of fatigue are as important in recreation as they are in work. For example, in walking and in other exercises short rest periods should be taken. The time when recreation is taken is just

as important as the recreation itself. Dancing, for example, if taken early in the evening, if the dances are short and without encores, may be indulged in with benefit and safety, but when the dance extends long after one's bedtime it becomes harmful and bad recreation. One should recall the experiments of Mosso, which show that muscles completely fatigued do not come back to their full strength for two hours, whereas, when only half fatigued they come back to full strength in half an hour. There should be more efforts made to provide recreation early in the evening so that one may take his recreation and still retire at his usual bedtime. Matinees are better than evening shows which keep one up until after 12. Recreation taken after one's usual time for retiring breaks up his regularity of life. It increases the amount of fatigue and becomes more and more harmful as the recreation continues longer and later. It is not a matter of making up the lost time in the morning, for like the muscles which take four times as long to come back when they were completely fatigued as when they were only half fatigued, so one may have to spend from two to four times as many hours later to make up for the recreation that is taken after one's usual bedtime, because of the more complete fatigue.

One may enjoy active recreation by proxy. In planning his recreation it may help the tuberculous person to think of himself as 20 years older than he really is. For just as a man changes his recreation as he grows older to more quiet and dignified kinds, so the tuberculous person must change to recreation that requires less physical activity. But this does not mean that he may not enjoy it by proxy. For example, one can not play baseball because it is too active. It requires the use of the chest muscles which stretches the lung tissue and may tear it because bound by the underlying pleurisy to the chest wall. It may delay recovery, if not permit a spread of the disease. But although one may not play he can go and enjoy a baseball game without effort or danger. So it is with other sports. One may not play lawn tennis, but he can enjoy a tennis match, or again, one may not be able to box, but he can attend a boxing bout. In other words, the tuberculous may enjoy his active sports and games, but he must enjoy them by proxy, that is, secondhand. This is not altogether a disadvantage, for one may have just as much fun and none of the discomforts.

The make-believe instinct is developed early. The girl likes to play that she is keeping house. A boy likes to play that he is an Indian or a "wild west" rider. By such actions they create the pleasurable sensations that they enjoy. The adult possesses the same instincts. He loves the drama and play, the novel, and the short story, because they create in him pseudo or false emotions—the same pleasurable sensations that the child developed by his make-believe. These kinds of recreations are beneficial. The growth of the moving-picture industry, the many short stories, and the popularity of the theater and the vaudeville indicate that they play a useful part in the recreation of modern life. Aside from the popularity and it being the thing to go to the theater, etc., these entertainments supply a human need. In the theater one is drawn away from himself. He forgets the cares of the day and by the plot and scenery of the play he is carried along in a state which is quite unreal and restful. It is a condition where things are not as they seem. One sees the villain choke the

heroine, but he is not moved to protect her. It is as if the evil and bad were suppressed and as though goodness and justice were supreme. In the play one may enjoy seeing evil and trouble because they are separated from reality. It reminds one somewhat of the condition of the elderly person who seems to enjoy having rheumatism. He loves to tell about his troubles. The novel and the short story produce the same pseudo or false emotions. By reading books one may visit, as it were, the various countries of the earth with none of the hardships and with all of the comforts. If one enjoys adventure and the frontier, he may buy books like the "Last of the Mohicans," one of the Leather Stocking Tales, and he may be carried backward in time and enjoy life in the open in the woods, infested by Indians, but with none of the dangers and privations that he would have had in real life; or if one enjoys animals or the study of bird life, by reading such books as "Tales of Wild Animals I Have Known," by Ernest Seaton Thompson, he is able to do this without fatigue and without physical effort in the comfort of his own home. And so through the list. Reading is an excellent form of recreation for the tuberculous. With the many public libraries found in every city and in many towns it is not necessary for one to travel many miles to secure a book as it was for Abraham Lincoln. Besides, the weekly and monthly magazines furnished a wide variety, at a very low cost. One should not read for the pseudo or false emotions alone. He should cultivate habits of reading for knowledge and information that will help him solve his daily social and domestic problems. The reading of something useful may be as much a recreation as something that merely passes the time and it is possible to form habits of recreation where the result is more than just a whiling away of one's time.

Man is a social animal. He enjoys being in groups and in crowds. He likes to live in cities where people are. For that reason clubs and societies of various kinds are excellent ways of taking recreation. Debating and literary societies, clubs, and classes for the consideration of special subjects as politics, current events, home study circles, etc., should be encouraged. They are excellent ways of enjoying recreation. Those who are interested in music should be encouraged to organize musical groups, choral societies, orchestras, etc. Community singing is excellent. Nearly everyone enjoys singing. Professional singing may not be advisable for the tuberculous, but community singing is suitable for those who are arrested. If one can not sing he may learn to whistle or hum. With the invention of the phonograph and player piano the best music is available at a reasonable cost. It is possible for nearly everyone to become acquainted with the best music that is sung and played by the leading artists of the United States and Europe. It is not necessary for one to understand the technique and the laws of harmony for one to enjoy the music any more than it is necessary for one to know all about the structure of a rose to appreciate its fragrance and beauty. There is nothing that is more useful than music to combat lonesomeness and homesickness, to create the pleasurable sensations, and to stimulate courage and increase the morale.

RECREATION AND REST.

While recreation is activity it may really be restful because different body cells are used and because of the tonic effect that the pleasurable sensations create in the whole body. The brain worker unless he is completely tired out is refreshed and rested by walking or golf. A good show acts as a nerve restorer. It has been found that recreation rooms for factory or office employees soon pay for themselves by the increased production of contented workers.

It is interesting to note that the Jews hundreds of years before Christ had developed many sanitary regulations which are described in the so-called books of Moses. All their meat was killed by the rabbis, or priests, who were trained in the detection of disease in animals, and just as they forbade the eating of diseased animals, which they could tell by inspection, they forbade the eating of pork to prevent trichina, a disease communicated to man by hogs, because they could not tell by examination in those days whether or not the hogs were diseased. So well did they understand the physiology of activity, rest, and fatigue that they established every seventh day as a rest period—the sabbath when no work was permitted. The Bible writer recognized that it was a physiological necessity that man have one day's rest in seven and he made it emphatic. He said that even in seed time and harvest no work shall be done.

We have found in our study of fatigue that short rest periods are necessary during the day and that a long period of rest during the night is needed to restore one's ability to do. We may not have thought but these rest periods go further. We need one day of rest in seven. There is, moreover, a growing tendency to believe that everyone should have a vacation of at least two weeks once or twice a year and some believe that every seven years one should have a change in work, if not a period of recreation, the so-called sabatical year. Sunday, the modern sabbath, is a day of rest. It is a truce or armistice with fatigue. True it is a day of rest, but it is also a day for recreation. It certainly should not be a day of misery or inhibition like the old puritanical sabbaths. For the Bible writer tells us that the sabbath was made for man and not man for the sabbath. From this it is evident that the sabbath was established primarily for health reasons as well as a day of worship. On the other hand, one should take his recreation so that it is really "anti-fatigue" and he is not more tired Monday morning than he was on the Saturday night.

Recreation presumes a condition of satisfaction, pleasure, or enjoyment. Such a condition we have learned is necessary for one's well-being. This was illustrated in the study of digestion where we learned that when a cat is irritated that digestion comes to a stop, that when it was petted and became pleased digestion started in again. The emotions of pleasure act as a tonic. They increase the tone of the muscles and body. They favor the vital processes and the production of energy. It has long been recognized that cheerful men recover more quickly after accidents and injuries. In times of war, rewards, prizes, and decorations have their advantage, for they create emotions of pleasure, they stimulate the morale and prepare

the troops to endure greater hardships, and in case of injury or sickness, to recover more quickly. For as Pare, the great French surgeon said, "Joyous men always recover."

HOBBIES AND SOCIAL SERVICE WORK.

It is possible to develop some hobby such as gardening where one may add to his dietary suitable green vegetables or in the cultivation of flowers to beautify his own home or to provide gifts for the sick. In fact one should seek every day to do some unselfish act or kindness for the benefit of one's fellowmen. To do a kindness is the ideal recreation. It is said that the great Roman emperor, Marcus Aurelius, was wont to think over at the close of the day what he had done, and that he was wont to say that he had lost a day if he could not recall having done some one a kindness or benefit.

Count that day lost whose low descending sun
Views from thy hand no worthy action done.

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